JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA

FOR THE

PROMOTION OF THE MECHANIC ARTS.

AUGUST, 1851.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

On the Comparative Qualities of the Metal Employed in the Construction of Railroads. *By* Hu L. Damsel.

Continued from page 21.

Attempts have been made to remedy the tendency of best iron to laminate, but from not sufficiently attending to the minutiæ of the manufacture, they have been but partially successful. An ingenious apparatus for twisting the rail bar, whilst it is in course of manufacturing, has been patented in the States, and also in England. Through the medium of powerful machinery, the bar is twisted while in its rough state, until the fibres of metal encircle the rail instead of lying in a direction parallel with its axis. The metal thus prepared, appears to be much better adapted for certain manufacturing purposes than that produced in the usual way; but its superiority, as alleged, for railway bars, is not so apparent. Indeed, on attentive consideration, it will be manifest that the twisting of the bar alone, cannot retard the laminating process, for the fibrous character of the metal still exists, though it has been forced into a spiral instead of its previous parallel direction in the bar.

An English manufacturer has patented a process for manfacturing what appears to be a nearer approach to an anti-laminating rail. His plan is to construct the upper or wearing part of the rail, from puddled charcoal iron, in the unwrought state, and the lower or non-wearing part, from such iron as is ordinarily used in manufacturing rails. By this arrangement of the materials, the formation of fibre is materially reduced. Its existence, however, even in a reduced degree, must exercise a prejudicial effect on the durability of the rail bar. Yet, notwithstanding this circum-

stance, rails made under this patent have stood considerable rolling with fewer instances of lamination than might have been expected.

But the high price which is charged for these rails in England, where charcoal iron readily sells at prices nearly double those of ordinary coke pig iron, has hitherto limited their employment to a few isolated experiments on some of the leading railways in that country. Besides which, there does not appear to be any sufficient reason why charcoal iron should be necessary to the production of an anti-laminating rail. The high character which charcoal iron possesses for purity and tenacity, and its peculiar fitness for numerous minor manufactures, has led to its adoption as a standard of quality for iron, without sufficiently considering the various purposes to which this metal is applied, and the very different circumstances under which it is employed. Common brands from coke and coal fuel furnaces, have been used in the manner in which this charcoal iron has been used, and with similar success. They produced rails equally free from lamina, and with the important advantage of not increasing the cost of production.

Although the rails thus manufactured contained less than the usual quantity of fibre, the disadvantage of having masses of various sizes in the same pile, the injurious effects from which has already been made known, must not be overlooked. Lamination from this cause exceeds that from all others, whence the necessity for equalizing the sectional dimensions of the pieces composing the pile. The disproportion between the masses of metal composing the patent pile is very great, and their liability to laminate from this cause is therefore imminent.

To discover means whereby wrought rails might be rolled from common metal, and yet be free from the laminated structure attendant on its employment, experimental trials were made with rails rolled from variously constructed piles, built up of common puddled iron, with and without the admixture of superior qualities. This was done with the view of ascertaining if the present system of piling could not be advantageously altered for one which, with little or no additional expense in manufacturing over that now incurred, would result in the production of a perfectly non-laminating rail. The object aimed at, therefore, was one which, if attained, would be of incalculable benefit to railroad companies.

The plan usually adopted, is to arrange the bars, whether these are of mill or puddled iron, side by side, and one on the other, till a pile is built of the required dimensions. By thus arranging them, the grain or fibre of all the bars runs in the same direction—longitudinally. This parallelism is maintained in the subsequent process of rolling, when the pile is distended from its original length of about 3 feet into a finished rail of from 24 to 26 feet long, but is reduced laterally and vertically from 7 inches wide and 9 inches high, equal to 63 sectional inches to a bar, averaging, perhaps, 6 square inches. The fibres of metal are thus distended longitudinally to 9 times their original length, and to meet this elongation, they are compressed into one-ninth of their original sectional area. The fibrous character of the metal continues, and is multiplied at each successive rolling, until, as is not unfrequently the case at iron works, it is no longer available for manufacturing purposes.

The remedy which the writer designed for this prevailing tendency to laminate consequent on the disposition of the plates or bars in parallel layers, was to withdraw a few of the long bars which ran the whole length of the pile, and replace them with a number of short ones, which were laid cross-wise to the others, and were therefore in length equal to the breadth of the pile.

The first piles constructed on this plan were wholly composed of puddled iron disposed in parallel layers, with the exception of the two upper layers, which were of best metal. The top layer of best metal was of the usual length, and was placed along the pile in the usual manner, but the one under it resting on the puddled bars, was composed of short pieces laid across the pile, with their grain or fibre at right angles with that of the others.

Apparently, this simple alteration in the disposition of the bars of metal composing the unwrought pile, could not affect the structural arrangement of the manufactured bar, but in reality it occasioned a most important change. The rails rolled from these piles were placed on cast iron blocks, standing 3 feet apart, and broken by blows from a heavy ram falling freely between fixed guides. The appearances presented by the fractured ends were very different from anything previously observed in rails. For a depth of full half an inch from the surface, the fractured metal presented the crystalline appearance of fine white cast iron, while the remainder of the rail exhibited the usual coarse fibrous character commonly observed in rail iron. Yet, although the contrast between the two metals was striking in the extreme, the line of junction was indiscernible, and the union of the two qualities appeared to have been effected in the most solid manner.

The alteration thus effected in the structure of the metal by the single layer laid across the pile, led to further experiments on piles with two cross-laid layers, having a thickness of long bars between; and in subsequent experiments the number was increased till every alternate layer was thus disposed. The effect of a second cross layer of best iron was to double the depth of the fine crystalline metal, but when this second layer was of puddled iron, the metal, when broken, appeared to be formed of larger crystals not unlike coarse white pig iron. The metal in the bars rolled from piles built up with layers laid alternately along and across the pile, could scarcely be distinguished in its appearances from cast metal, so great had been the change which the altered mode of piling had effected in the structural arrangement of the iron.

By placing a cross layer of short bars at the head and foot of the pile, the rail when broken exhibited the crystalline structure at the top and bottom, with a centre mass of fibrous metal, and on placing cross layers in the middle of the pile only, the rail was found fibrous at both top and bottom, but crystalline in the middle. It is possible, therefore, to produce rails with non-fibrous metal in any desired proportion, and occupying any desired position.

The experiments on the conversion of fibrous into crystalline iron at pleasure, by merely altering the system of piling, satisfactorily demonstrated that, by disposing a moiety of the bars across, instead of along

the pile, as was heretofore the universal practice, a rail perfectly devoid of lamina could be manufactured from highly fibrous metal. The additional expense from using the short cross bars over that incurred in the usual way, amounted to about ten cents per ton on the rails experimented upon; but in the event of the plan being generally adopted, as it is presumed it will be, there being no patent right to contend with, the additional expense from the extra labor in shearing, will probably not exceed three or four cents per ton.

These highly favorable results, exceeding as they did the most sanguine expectations of the writer, led to an inquiry respecting the origin and nature of fibre in wrought iron.

It is known to metallurgists that crude bar iron, as drawn from the puddling furnace, is devoid of any fibre; and that this property is developed only in the more advanced stages of the manufacture. If the bloom of puddled iron is worked under a hammer, fi[illegible] may be produced in any desired direction, or, the operation may be so conducted that the resultant mass shall possess no perceptible fibre; but metallic bars elongated by rolling will possess fibre in the direction of their length. The iron from the puddling rolls displays a few fibres, which are, in the subsequent processes of reheating and rolling, rapidly multiplied, as described in a previous paper, until the bar appears to be one mass of longitudinal fibres. These have been produced by the mechanical action of the rolls elongating the bar in one direction only. The heavy revolving rolls by their transverse pressure on the bar, force the fibres in it to occupy a lateral position. So long as the bar passes between these rolls endwise, the fibre will exist in this direction. Let the bar, however, be passed sideways a few times, and their direction will be totally changed. If a short piece is cut from off the end of a fibrous bar, and rolled a few times in a direction at right angles with its former axis, so as to distend its linear dimension, the fibre will be found running the length of the bar, though at first it was direct across. The direction of the original fibres has been obliterated, and new fibres have been formed. Continuing the rolling in this direction, and a bar of fibrous wrought iron will be produced, equal in tenacity to one rolled continuously in the same direction. It is very evident, however, that at a certain stage in the operation, this rolling of the bar at a right angle to its former direction, will have merely neutralized the effect of the previous rolling, without producing new fibre. If examined at this stage, the bar will be found free from lamina, and equally strong in every direction. It has been discovered by experiment, that to arrive at this point with certainty and precision, the operation must be so conducted that the elongation or distension of the metal shall be similar in each direction. The puddled bars used in the piles, which subsequently formed the rails experimented on, were rolled from blooms about 12 inches long, into bars averaging 12 feet long, by 3 inches wide. Their linear dimension was consequently increased twelve-fold. The short pieces cut from off these bars and laid transversely in the pile, were 7 inches long and 3 inches wide; by the combined lateral and vertical strains which they were subjected to in the operation of rolling the rail, they were distended to nine times their former length, or to 27 inches,

long, with a considerable diminution in their breadth and thickness, equivalent on the whole, to the twelve-fold distension by the original rolling.

Apart from the great advantage of a non-laminating metal, the rails prepared under this plan of cross-piling, displayed qualities which rendered them peculiarly valuable for railway purposes. When tested by a heavy weight falling freely on them from a height of fourteen feet, the indentation occasioned by the impact was very much less than that on rails manufactured in the usual way; and tested by supporting them at the ends, and suspending a weight of two tons for a few minutes on their centre, the permanent deflexion was also found greatly in favor of the cross-piling. The mechanical action of the rolls in neutralizing the previous fibrous structure, appears to have condensed the particles of metal, and to have violently expelled the cinder and other extraneous matter with which it was combined. The increased rigidity appears also to have resulted from the increased density of the metal in the upper portion of the bar, offering a greater resisting medium to compression.

This neutralizing the tendency of bar iron to resolve into the fibrous structure, is partially understood in the manufactures of boiler plate and sheet iron. The plan followed in these factories consists in alternately presenting the end and side of the plate to the action of the rolls, whereby the expansion of the metal is equal in each direction; but this procedure, though well adapted to neutralize the formation of fibre when the object operated on is a plain iron plate, is inapplicable in the case of rails by reason of their angular section and great length—circumstances which render it essentially necessary that their movements be in the same plane.

The system of cross-piling herein described, involves a principle of great importance hitherto comparatively unknown to manufacturers of wrought iron. By its application, the tendency of rolled bar iron generally to resolve into the fibrous structure, is effectually prevented. By its application, also, the surface or even the entire depth of rail bars, are hardened so that abrasion from the sliding of the rolling and working stock is reduced, and the rigidity of the rail is increased. The simplicity of the remedy, the facility with which it may be managed, and the unerring certainty that the metal so worked will be devoid of lamina, must eventually secure its introduction into iron works generally.

The beneficial application of the principle, however, is not limited to the manufacture of non-laminating rails; it may be advantageously extended to various descriptions of wrought iron for engineering and building purposes, where a partial or total absence of lamina is desired. In the manufacture of wheel tyres, it will be found especially valuable; in manufacturing roofing and other iron, it may be used with considerable economy of materials; its qualities of rigidity and tenacity combined, will render it of essential service to iron ship builders; to steam boiler makers and others, requiring angle iron possessing a tenacity equal in every direction, it must prove of great importance; while the facility with which the rigidity and hardness of cast iron can be communicated to wrought iron without impairing its tenacity, will doubtless ensure its extensive adoption in the manufacture of malleable iron frames for the engines of ocean-going steamers.

On the Pneumatic Method adopted in constructing the Foundations of the new Bridge across the Medway, at Rochester. *By* JOHN HUGHES, Assoc. Inst. C. E.*

This bridge was described as being designed to consist of three large openings, a central one of 170 feet in width, and two others, each of 140 feet in width, spanned by cast iron segmental girders, and of a passage to admit masted vessels to the upper parts of the river, across which a moveable bridge would be placed. Each of the river piers occupied an area of 1118 square feet, and rested upon a series of cast iron cylinder piles, 7 feet in diameter, placed 9 feet apart longitudinally, and 10 feet transversely, so that there were fourteen under each pier. The cylinder piles in the abutments were 6 feet in diameter, of which the "Strood" abutment required thirty, and the "Rochester" abutment twelve. Each pile was composed of two, three, or more cylinders, 9 feet in length, bolted together through stout flanches; the bottom length had its lower edge bevelled, so as to faciliate the cutting through the ground. The bed of the river was originally presumed to consist of soft clay, sand, and gravel, overlying the chalk, and accordingly the application of Dr. Potts' pneumatic method for forcing the cylinder piles into the ground, which had been successfully carried out in similar positions, was contemplated; but after a few trials, the ground was found to consist of a compact mass of Kentish ragstone, so that the mere atmospheric action upon the piles, induced by a partial vacuum, would be ineffective in such a situation. It was therefore decided, that the pneumatic process should be reversed, so as to give each pile the character of a diving-bell; for which purpose one of the cylinders, 7 feet in diameter, and 9 feet in length, had a wrought iron cover securely bolted to it, through which two cast iron chambers, D shaped in plan, with a sectional area of about 6 square feet appropriately called "air locks," projected 2 feet 6 inches above the top of the cylinder, and 3 feet 9 inches below the cover. The top of each "air lock" was provided with a circular opening 2 feet in diameter, with a flap working on a horizontal hinge, and an iron door, 2 feet by 3 feet 4 inches, with vertical hinges below the cover; each air lock was also furnished with two sets of cocks, the one for forming a communication between the cylinders and the chamber, and the other between the chamber and the atmosphere. Compressed air was supplied to the cylinder pile by a double-barrelled pump, 12 inches in diameter, and 18 inches stroke, driven by a six horse power non-condensing steam engine. At first the expelled water was made to pass into the river, from beneath the lower edge of the piles, but when the stratum became so compact as to oppose a high degree of resistance to the passage of the air, an outlet was formed through the side of the uppermost cylinder, by the introduction of a pipe having the form of a syphon, the long leg of which reached to the bottom of the pile, and was subject to the pressure of the condensed air on the surface of the water within, whilst the short leg leading into the river, had the effect of relieving the amount of compression, provided a vacuum was once obtained in the body of the syphon. Such an effect was readily produced by connecting the summit with the exhaust side of the air pumps, by a pipe, which could be opened or closed at pleasure. To insure the downward motion of the pile, and to give it a weight

* From the London Architect, for June, 1851.

which should be at all times superior to the upward pressure, two stout trussed timber beams were laid on the top of the cylinder, in a direction suitable for bringing the adjacent piles into action as counterbalance weights, by four chains passing over cast iron sheaves.

Two light wrought-iron cranes were fixed inside the cylinder, the jibs of which swept over the space between the air locks and windlasses, inside and outside, for the purpose of hoisting the loaded buckets, and lowering the empty ones.

The method followed in working the apparatus was found to be so simple in detail, as to be perfectly intelligible to all the workmen employed. The pumps being set in motion, the flap of one of the air locks and the door of the other, were closed; a few strokes compressed the air within the pile sufficiently to seal the joints, and whilst the pumping was in progress, the men passed through the air locks to their respective stations. When the water was shallow, the pile descended, by scarcely sensible degrees, as fast as the excavation by hand permitted; when the water was deep, the excavation was carried down full 14 inches below the edge of the pile, which then descended, at once, through the whole space, as soon as the pressure was eased off.

The most perfect certainty and success had attended the employment of this simple system, and as it promised to afford considerable assistance to engineers in the prosecution of similar works, the author laid the account before the Institution with the sanction of Mr. Cubitt, President Inst. C. E., the engineer-in-chief, and Messrs Fox, Henderson, and Co., the contractors for the works —*Proc. Inst. Civ. Eng. May 13th*, 1851.

Railway over the Soemmering Mountain, Austria.

This railroad is assuredly one of the most important public works ever executed in Europe, both as regards the fact of its establishing a communication with the Adriatic, and the considerable height it has to pass. The number of persons employed, when the greatest activity was displayed in pushing the work forward, amounted to 16,000 men, and 2000 women and children. The cholera broke out last season among these workpeople, in consequence of their not being properly housed, which in some degree even interrupted the progress of the undertaking.

The height of the Soemmering at the spot where the railroad will pass, is 3066 feet above the level of the sea; but a tunnel is to be bored in the mountain at a height of 2790 feet. 1200 men and twelve steam engines of an aggregate power of 200 horses, are employed in this tunnel, which is called the Soemmering Haupt Tunnel, and the length of which is about one English mile. Four millions cubic feet of stone and earth will have to be displaced, at a cost of 150,000*l*. The estimated cost of the whole Soemmering railway, is 800,000*l*., but will probably amount to a million. As the length is 5 German miles, (20 English), each mile will require an outlay of nearly 200,000*l*. This sum is large; but the railroad on the Prussian and Belgian frontiers exceeded

* From the London Architect, for June, 1851.

it, and cannot be compared with that over the Soemmering. Owing to the brittle nature of the limestone rock, the excavation of the tunnel has to be effected with great precaution. The carrying away of the debris, and the bringing in the building materials, through the complicated scaffolding, is very laborious. The arches of the tunnel have, in some places, been made double and treble, one above the other, which are considered better than a single one of the same thickness.

But even viewing these operations under the most hopeful aspect, doubts seem now to rise, whether such an expensive and, even when successfully completed, *hazardous* passage might not have been avoided by flanking this whole mountain range, and carrying the road to Trieste through the valleys of Hungary. The most critical points on the line are the many short curves it presents, and steep gradients, in some places 1 in 40 for a length of two English miles.

The time is approaching when the prize of 20,000 ducats (about 10,000*l.*) will be awarded for an engine to surmount all these difficulties. One of the conditions is, that it must be applicable to curves whose radius, in one instance, is no more than 600 feet—one of the most difficult problems ever proposed. Unhappily, the deep snow spreading every winter over these sub-alpine regions, has stayed the progress of the works; and it may, as has been apprehended, stay the traffic, if once completed.

For the Journal of the Franklin Institute.

A New Method of Calculating the Cubic Contents of Excavations and Embankments.—By John C. Trautwine, C. E.

Entered, according to the Act of Congress, in the year 1851, by John C. Trautwine, in the Clerk's Office of the District Court of the United States, for the Eastern District of Pennsylvania.

Continued from page 13.

In the following tables of level cuttings, the left hand vertical column contains the height or depth of the embankment or excavation, in feet; and the upper horizontal column, the intermediate tenths of a foot. Thus in table 1, the cubic yards in a station 100 feet long and 10 feet deep, are 1074; for 10·1 deep, 1090; for 10·2 deep, 1107, &c.

Errata.

The following errata occur in the first portion of this article, in the preceding number of the Journal.

Page 5, Fifth line from the top, for 78°58′, read 75°58′.

" 22 lines from bottom, for *e f* or width of roadway, read *o f* or half width of roadway. And in the following four lines, for *e f* read *o f*.

Page 8, 16 lines from top, for ½ to 1, read ¼ to 1.

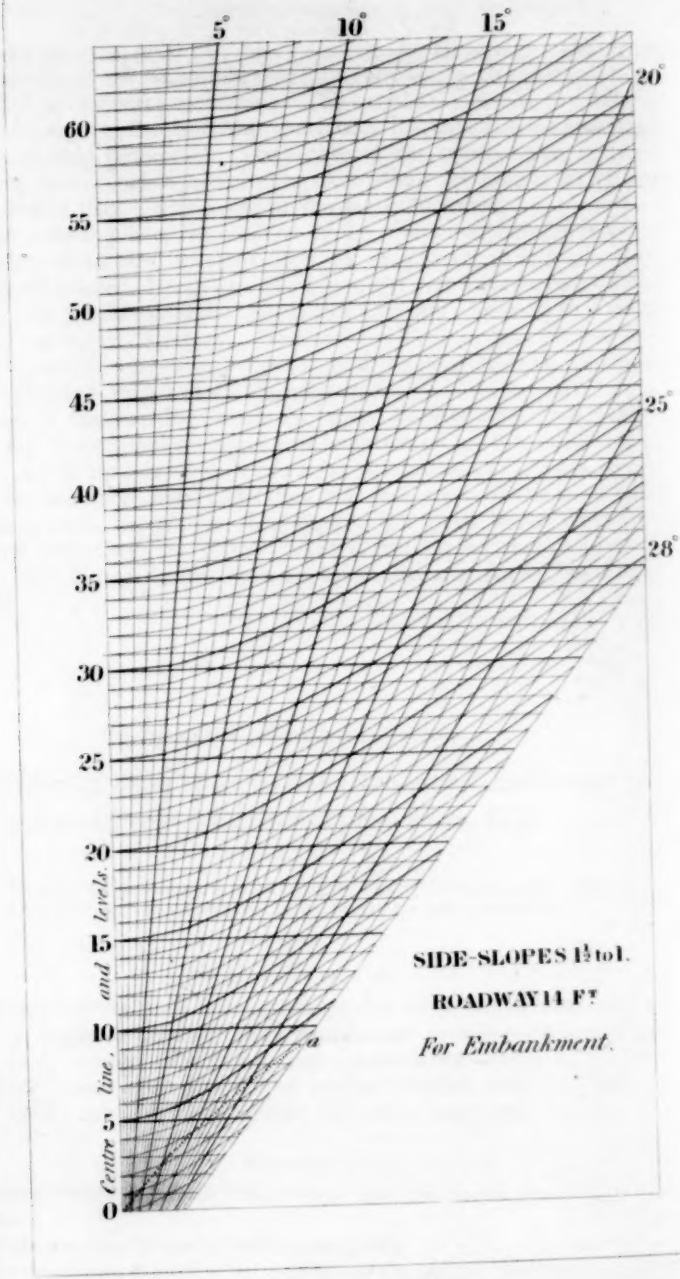

5°
10°
15°
20°
25°
28°
60
55
50
45
40
35
30
25
20
15
10
5
0
Centre line, and levels.
a
SIDE-SLOPES 1½ to 1.
ROADWAY 14 Ft
For Embankment.

TABLE 1.—LEVEL CUTTINGS.

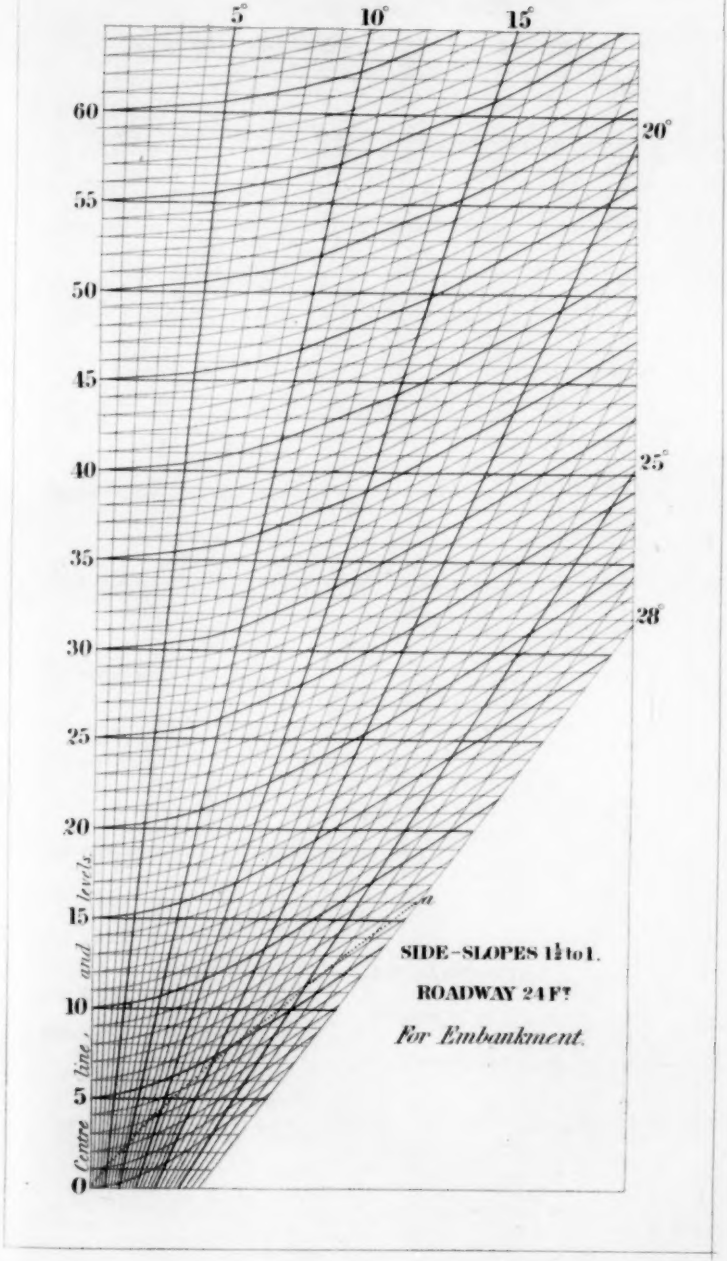
Roadway 14 *feet wide, side-slopes* 1½ *to* 1.

H'ght in ft.	0	·1	·2	·3	·4	·5	·6	·7	·8	·9
	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds	cu. yds.	cu. yds.	cu. yds.
0		5·24	10·6	16·1	21·6	27·3	33·1	39·0	45·0	51·2
1	57·4	63·8	70·2	76·8	83·5	90·3	97·2	104·2	111·3	118·6
2	125·9	133·4	141·0	148·6	156·4	164·4	172·4	180·5	188·7	197·1
3	205·6	214·1	222·8	231·6	240·5	249·5	258.7	267·9	277·3	286·7
4	296·3	306·0	315·8	325·7	335·7	345.8	356·1	366·4	376·9	387·5
5	398·1	408·9	419·9	430·9	442·0	453·2	464·6	476·1	487·6	499·3
6	511·1	523·0	535·0	547·2	559·4	571·8	584·2	596·8	609·5	622·3
7	635·2	648·2	661·3	674·6	687·9	701·4	714·9	728·6	742·4	756.3
8	770·3	784·5	798·7	813·1	827·5	842·1	856·8	871·6	886·5	901·5
9	916·7	931·9	947·3	962·7	978·3	994·0	1010	1026	1042	1058
10	1074	1090	1107	1123	1140	1157	1174	1191	1208	1225
11	1243	1260	1278	1295	1313	1331	1349	1367	1385	1404
12	1422	1441	1459	1478	1497	1516	1535	1554	1574	1593
13	1613	1633	1652	1672	1692	1712	1733	1753	1773	1794
14	1815	1835	1856	1877	1898	1920	1941	1962	1984	2006
15	2028	2050	2072	2094	2116	2138	2161	2183	2206	2229
16	2252	2275	2298	2321	2344	2368	2391	2415	2439	2463
17	2487	2511	2535	2559	2584	2608	2633	2658	2683	2708
18	2733	2759	2784	2809	2835	2861	2886	2912	2938	2964
19	2991	3017	3044	3070	3097	3124	3151	3178	3205	3232
20	3259	3287	3314	3342	3370	3398	3426	3454	3482	3510
21	3539	3557	3586	3615	3644	3673	3702	3731	3761	3790
22	3820	3849	3879	3909	3939	3969	3999	4030	4060	4091
23	4132	4162	4193	4224	4255	4287	4318	4349	4381	4413
24	4444	4476	4508	4541	4573	4605	4638	4670	4703	4736
25	4769	4802	4835	4868	4901	4935	4968	5002	5036	5070
26	5104	5138	5172	5206	5241	5275	5310	5345	5380	5415
27	5450	5485	5521	5556	5592	5627	5663	5699	5735	5771
28	5807	5844	5880	5917	5953	5990	6027	6064	6101	6139
29	6176	6213	6251	6289	6326	6364	6402	6140	6479	6517
30	6556	6594	6633	6672	6711	6750	6789	6828	6867	6907
31	6946	6986	7026	7066	7106	7146	7186	7226	7267	7307
32	7348	7389	7430	7471	7512	7553	7596	7636	7678	7719
33	7761	7803	7845	7887	7929	7972	8014	8057	8099	8142
34	8185	8228	8271	8315	8358	8401	8445	8489	8532	8576
35	8620	8664	8709	8753	8798	8842	8887	8932	8976	9022
36	9067	9112	9157	9203	9248	9294	9340	9386	9432	9478
37	9524	9570	9617	9663	9710	9757	9804	9851	9898	9945,
38	9993	10040	10088	10135	10183	10231	10279	10327	10375	10424
39	10472	10521	10569	10618	10667	10716	10765	10815	10864	10913
40	10963	11012	11062	11112	11162	11212	12263	11313	11364	11414
41	11465	11516	11567	11618	11669	11720	11771	11823	11874	11926
42	11978	12029	12081	12134	12186	12238	12291	12343	12396	12449
43	12502	12555	12608	12661	12715	12768	12822	12875	12929	12983
44	13037	13091	13145	13200	13254	13309	13363	13418	13473	13528
45	13583	13639	13694	13749	13805	13861	13916	13972	14028	14084
46	14141	14197	14254	14310	14367	14424	14480	14537	14595	14652
47	14709	14767	14824	14882	14940	14998	15056	15114	15172	15230
48	15289	15347	15406	15465	15524	15583	15642	15701	15761	15820
49	15880	15939	15999	16059	16119	16179	16239	16300	16360	16421
50	16481	16542	16603	16664	16725	16787	16848	16909	16971	17033
51	17094	17156	17218	17281	17343	17405	17467	17530	17593	17656
52	17719	17782	17845	17908	17971	18035	18098	18162	18226	18290
53	18354	18418	18482	18546	18611	18675	18740	18805	18870	18935
54	19000	19065	19131	19196	19262	19327	19393	19459	19525	19591
55	19657	19724	19790	19857	19923	19990	20057	20124	20191	20259
56	20326	20393	20461	20529	20596	20664	20732	20800	20869	20937
57	21005	21074	21143	21212	21280	21349	21419	21488	21557	21627
58	21696	21766	21836	21906	21976	22046	22116	22186	22257	22327
59	22398	22469	22540	22611	22682	22753	22825	22896	22968	23039
60	23111	23183	23255	23327	23399	23472	23544	23617	23689	23762

TABLE 2.—LEVEL CUTTINGS.

Roadway 24 feet wide, side-slopes 1½ to 1.

Height in ft.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.
0		8·94	18·0	27·2	36·4	45·8	55·3	64·9	74·7	84·5
1	94·4	104·5	114·7	124·9	135·3	145·8	156·4	167·2	178·0	188·9
2	200·0	211·2	222·4	233·8	245·3	256·9	268·6	280·5	292·4	304·4
3	316·6	328·9	341·2	353·7	366·3	379·0	391·9	404·8	417·8	431·0
4	444·4	457·8	471·3	484·9	498·6	512·4	526·4	540·4	554·6	568·8
5	583·3	597·8	612·4	627·1	642·0	656·9	671·9	687·1	702.3	717·7
6	733·3	748·9	764·7	780·5	796·4	812·5	828·7	844·9	861·3	877·8
7	894·4	911·2	928·0	944·9	962·0	979·2	996·4	1014	1031	1049
8	1067	1085	1102	1121	1139	1157	1175	1194	1212	1231
9	1250	1269	1288	1307	1326	1346	1365	1385	1405	1425
10	1444	1465	1485	1505	1525	1546	1566	1587	1608	1629
11	1650	1671	1692	1714	1735	1757	1779	1800	1822	1845
12	1867	1889	1911	1934	1956	1979	2002	2025	2048	2071
13	2094	2118	2141	2165	2189	2213	2236	2261	2285	2309
14	2333	2358	2382	2407	2432	2457	2482	2507	2532	2558
15	2583	2609	2635	2661	2686	2713	2739	2765	2791	2818
16	2844	2871	2898	2925	2952	2979	3006	3034	3061	3089
17	3117	3145	3172	3201	3229	3257	3285	3314	3342	3371
18	3400	3429	3458	3487	3516	3546	3575	3605	3635	3665
19	3694	3725	3755	3785	3815	3846	3876	3907	3938	3969
20	4000	4031	4062	4094	4125	4157	4189	4221	4252	4285
21	4317	4349	4381	4414	4446	4479	4512	4545	4578	4621
22	4644	4678	4711	4745	4779	4813	4846	4881	4915	4949
23	4983	5018	5052	5087	5122	5157	5192	5227	5262	5298
24	5333	5369	5405	5441	5476	5513	5549	5585	5621	5658
25	5694	5731	5768	5805	5842	5879	5916	5954	5991	6029
26	6067	6105	6142	6181	6219	6257	6295	6334	6372	6411
27	6450	6489	6528	6567	6606	6646	6685	6725	6765	6805
28	6844	6885	6925	6965	7005	7046	7086	7127	7168	7209
29	7250	7291	7332	7374	7415	7457	7499	7541	7582	7625
30	7667	7709	7751	7794	7836	7879	7922	7965	8008	8051
31	8094	8138	8181	8225	8269	8313	8356	8401	8445	8489
32	8533	8578	8622	8667	8712	8757	8802	8847	8892	8938
33	8983	9029	9075	9121	9166	9212	9259	9305	9351	9398
34	9444	9491	9538	9585	9632	9679	9726	9774	9821	9869
35	9917	9965	10012	10061	10109	10157	10205	10254	10302	10351
36	10400	10449	10498	10547	10596	10646	10695	10745	10795	10845
37	10894	10945	10995	11045	11095	11146	11196	11247	11298	11349
38	11400	11451	11502	11554	11605	11657	11709	11761	11812	11865
39	11917	11969	12021	12074	12126	12179	12232	12285	12338	12391
40	12444	12498	12551	12605	12659	12713	12766	12821	12875	12929
41	12983	13038	13092	13147	13202	13257	13312	13367	13422	13478
42	13533	13589	13645	13701	13756	13813	13869	13925	13981	14038
43	14094	14151	14208	14265	14322	14379	14436	14494	14551	14609
44	14667	14725	14782	14840	14899	14957	15015	15074	15132	15191
45	15250	15309	15368	15427	15486	15546	15605	15665	15725	15785
46	15844	15905	15965	16025	16085	16146	16206	16267	16328	16389
47	16450	16511	16572	16634	16695	16757	16819	16881	16942	17005
48	17067	17129	17191	17254	17316	17379	17442	17505	17568	17631
49	17694	17758	17821	17885	17949	18013	18076	18141	18205	18269
50	18333	18398	18462	18527	18592	18657	18722	18787	18852	18918
51	18983	19049	19115	19181	19246	19313	19379	19445	19511	19578
52	19644	19711	19778	19845	19912	19979	20046	20114	20181	20249
53	20317	20385	20452	20521	20589	20657	20725	20794	20862	20931
54	21000	21069	21138	21207	21276	21346	21415	21485	21555	21625
55	21694	21765	21835	21905	21975	22046	22116	22187	22258	22329
56	22100	22471	22542	22614	22685	22757	22829	22901	22972	23045
57	23117	23189	23261	23334	23406	23479	23552	23625	23698	23771
58	23844	23918	23991	24065	24139	24213	24286	24361	24435	24509
59	24583	24658	24732	24807	24882	24957	25032	25107	25182	25258


5°
10°
15°
20°
25°
28°
60
55
50
45
40
35
30
25
20
15
10
5
0
Centre line and levels
a
SIDE-SLOPES 1½ to 1.
ROADWAY 24 Ft.
For Embankment.

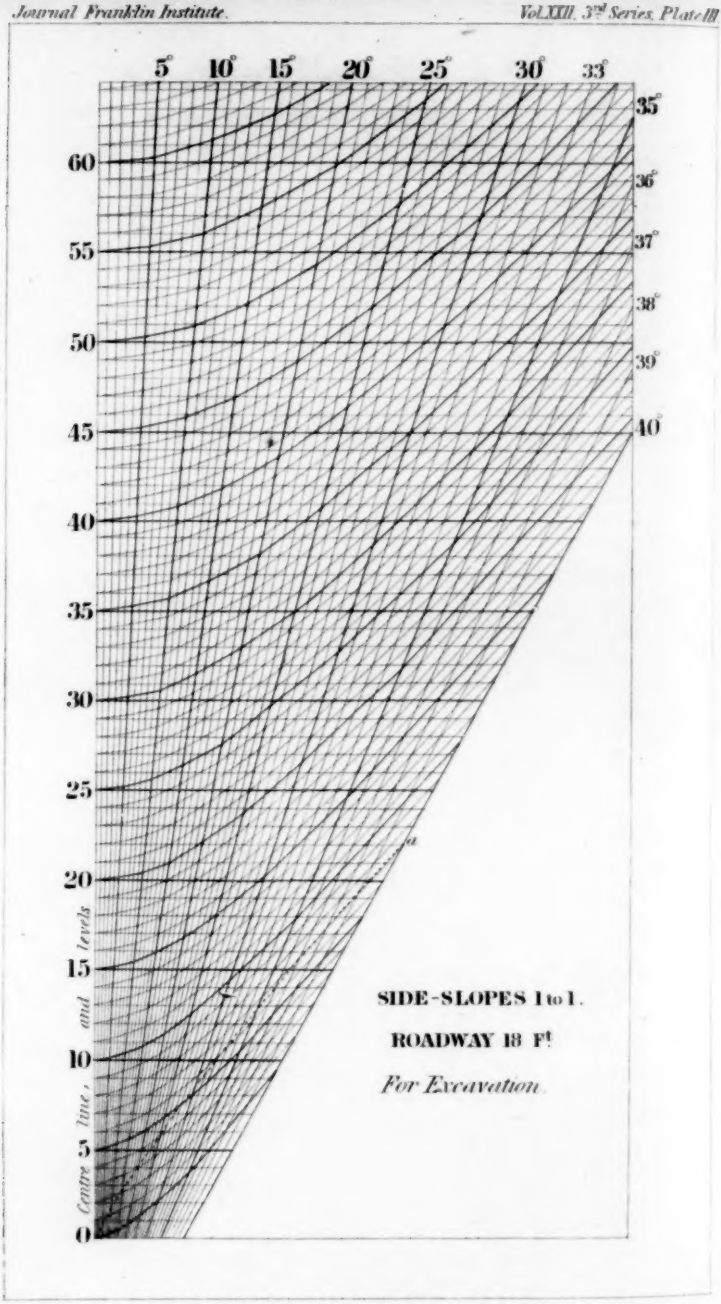

5° 10° 15° 20° 25° 30° 33°
35°
36°
37°
38°
39°
40°
60
55
50
45
40
35
30
25
20
15
10
5
0
Centre line, and levels
a
SIDE-SLOPES 1 to 1.
ROADWAY 18 Ft.
For Excavation.

TABLE 3.—LEVEL CUTTINGS.

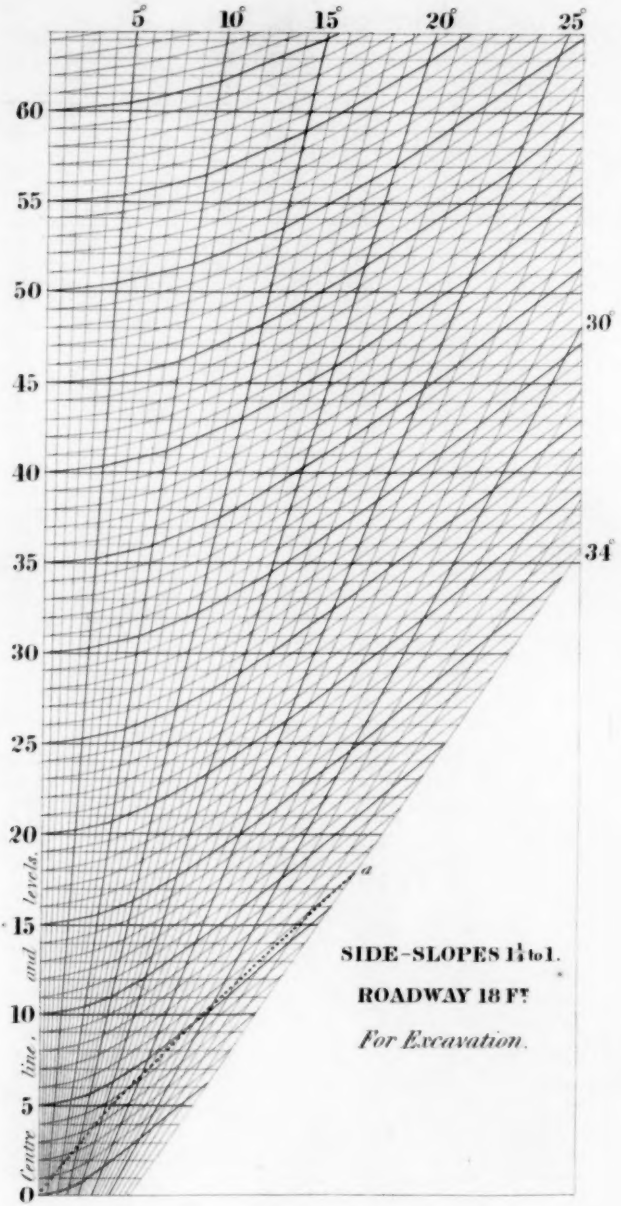
Roadway 18 *feet wide, side-slopes* 1 *to* 1.

Depth in ft.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.
0		6·70	13·5	20·3	27·3	34·3	41·3	48·5	55·7	63·0
1	70.4	77·8	85·3	92·9	100·6	108·3	116·1	124·0	132·0	140·0
2	148·1	156·3	164·6	172·9	181·3	189·8	198·4	207·0	215·7	224·5
3	233·3	242·3	251·3	260·3	269·5	278·7	288·0	297·4	306·8	316·3
4	325·9	335·6	345·3	355·1	365·0	375·0	385·0	395·1	405·3	415·6
5	425·9	436·3	446·8	457·4	468·0	478·7	489·5	500.3	511·3	522·3
6	533·3	544·5	555·7	567·0	578·4	589·8	601·3	612·9	624·6	636·3
7	648·1	660·0	672·0	684·0	696·1	708·3	720·6	732·9	745·3	757·8
8	770·4	783·0	795·7	808·5	821·3	834·3	847·3	860·3	873·5	886·7
9	900·0	913·4	926·8	940·3	953·9	967·6	981·3	995·1	1009	1023
10	1037	1051	1065	1080	1094	1108	1123	1137	1152	1167
11	1181	1196	1211	1226	1241	1256	1272	1287	1302	1318
12	1333	1349	1365	1380	1396	1412	1428	1444	1460	1476
13	1493	1509	1525	1542	1558	1575	1592	1608	1625	1642
14	1659	1676	1693	1711	1728	1745	1763	1780	1798	1816
15	1833	1851	1869	1887	1905	1923	1941	1960	1978	1996
16	2015	2033	2052	2071	2089	2108	2127	2146	2165	2184
17	2204	2223	2242	2262	2281	2301	2321	2340	2360	2380
18	2400	2420	2440	2460	2481	2501	2521	2542	2562	2583
19	2604	2624	2645	2666	2687	2708	2729	2751	2772	2793
20	2815	2836	2858	2880	2901	2923	2945	2967	2989	3011
21	3033	3056	3078	3100	3123	3145	3168	3191	3213	3236
22	3259	3282	3305	3328	3352	3375	3398	3422	3445	3469
23	3493	3516	3540	3564	3588	3612	3636	3660	3685	3709
24	3733	3758	3782	3807	3832	3856	3881	3906	3931	3956
25	3981	4007	4032	4057	4083	4108	4134	4160	4185	4211
26	4237	4263	4289	4315	4341	4368	4394	4420	4447	4473
27	4500	4527	4553	4580	4607	4634	4661	4688	4716	4743
28	4770	4798	4825	4853	4881	4908	4936	4964	4992	5020
29	5048	5076	5105	5133	5161	5190	5218	5247	5276	5304
30	5333	5362	5391	5420	5449	5479	5508	5537	5567	5596
31	5626	5656	5685	5715	5745	5775	5805	5835	5865	5896
32	5926	5956	5987	6017	6048	6079	6109	6140	6171	6202
33	6233	6264	6296	6327	6358	6390	6421	6453	6486	6516
34	6548	6580	6612	6644	6676	6708	6741	6773	6805	6838
35	6870	6903	6936	6968	7001	7034	7067	7100	7133	7167
36	7200	7233	7267	7300	7334	7368	7401	7435	7469	7503
37	7537	7571	7605	7640	7674	7708	7743	7777	7812	7847
38	7881	7916	7951	7986	8021	8056	8092	8127	8162	8198
39	8233	8269	8305	8340	8376	8412	8448	8484	8520	8556
40	8593	8629	8665	8702	8738	8775	8812	8848	8885	8922
41	8959	8996	9033	9071	9108	9145	9183	9220	9258	9296
42	9333	9371	9409	9447	9485	9523	9561	9600	9638	9676
43	9715	9753	9792	9831	9869	9908	9947	9986	10025	10064
44	10104	10143	10182	10222	10261	10301	10341	10380	10420	10460
45	10500	10540	10580	10620	10661	10701	10741	10782	10822	10863
46	10904	10944	10985	11026	11067	11108	11149	11191	11232	11273
47	11315	11356	11398	11440	11481	11523	11565	11607	11649	11691
48	11733	11776	11818	11860	11903	11945	11988	12031	12073	12116
49	12159	12202	12245	12288	12332	12375	12418	12462	12505	12549
50	12593	12636	12680	12724	12768	12812	12857	12900	12945	12989
51	13033	13078	13122	13167	13212	13256	13301	13346	13391	13436
52	13481	13527	13572	13617	13663	13708	13754	13800	13845	13891
53	13937	13983	14029	14075	14121	14168	14214	14260	14307	14353
54	14400	14447	14493	14540	14587	14634	14681	14728	14776	14823
55	14870	14918	14965	15013	15061	15108	15156	15204	15252	15300
56	15348	15396	15445	15493	15541	15590	15638	15687	15736	15784
57	15833	15882	15931	15980	16029	16079	16128	16177	16227	16276
58	16326	16376	16425	16475	16525	16575	16625	16675	16725	16776
59	16826	16876	16927	16977	17028	17079	17129	17180	17231	17282
60	17333	17384	17436	17487	17538	17590	17641	17693	17745	17796

TABLE 4.—LEVEL CUTTINGS.

Roadway 18 *feet wide, side-slopes* 1½ *to* 1.

Depth in ft.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.
0		6·71	13·5	20·4	27·4	34·5	41·6	49·0	56·0	64·0
1	71·3	78·9	86·7	94·5	102·4	110·4	118·5	126·7	135·0	143·4
2	151·8	160·4	169·1	177·8	186·7	195·6	204·6	213·8	223·0	232·3
3	241·6	251·1	260·7	270·4	280·2	290·0	300·0	310·1	320·2	330·5
4	340·7	351·2	361·7	372·3	383·0	393·8	404·7	415.7	426·8	437·9
5	449·2	460·6	472·1	483·7	495·3	507·0	518·8	530·8	542·8	554·9
6	565·7	579·0	591·3	603·8	616·4	629·0	641.8	654·5	667·5	680.4
7	693·5	706·7	720·0	733·4	746·9	760·4	774·1	787·8	801·7	815·6
8	829·6	843·8	858·0	872·3	886·7	901·2	915·8	930·4	945·2	960·1
9	975·0	990·0	1005	1020	1036	1051	1067	1082	1098	1114
10	1130	1146	1162	1178	1194	1210	1227	1243	1260	1277
11	1293	1310	1327	1344	1361	1379	1396	1413	1431	1448
12	1467	1484	1502	1520	1539	1557	1575	1593	1612	1630
13	1649	1668	1687	1706	1725	1744	1763	1782	1802	1821
14	1841	1860	1880	1900	1920	1940	1960	1980	2001	2021
15	2042	2062	2083	2104	2125	2146	2167	2188	2209	2231
16	2252	2273	2295	2317	2339	2361	2383	2405	2427	2449
17	2471	2494	2516	2539	2562	2585	2608	2631	2654	2677
18	2700	2723	2747	2770	2794	2818	2842	2866	2890	2914
19	2938	2962	2987	3011	3036	3060	3085	3110	3135	3160
20	3185	3210	3236	3261	3287	3312	3338	3364	3390	3416
21	3442	3468	3494	3520	3547	3573	3600	3627	3654	3680
22	3707	3734	3762	3789	3816	3844	3871	3899	3927	3954
23	3982	4010	4039	4067	4095	4123	4152	4180	4209	4238
24	4267	4296	4325	4354	4383	4412	4442	4471	4501	4530
25	4560	4590	4620	4650	4680	4710	4741	4771	4802	4832
26	4863	4894	4925	4956	4987	5018	5049	5080	5112	5143
27	5175	5207	5239	5270	5302	5334	5367	5399	5431	5464
28	5496	5529	5562	5594	5627	5660	5693	5727	5760	5793
29	5827	5860	5894	5928	5962	5996	6030	6064	6098	6132
30	6167	6201	6236	6270	6305	6340	6375	6410	6445	6480
31	6516	6551	6587	6622	6658	6694	6730	6766	6802	6838
32	6874	6910	6947	6983	7020	7057	7093	7130	7167	7204
33	7242	7279	7316	7354	7391	7429	7467	7504	7542	7580
34	7618	7656	7695	7733	7772	7810	7849	7887	7926	7965
35	8005	8044	8083	8122	8162	8201	8241	8280	8320	8360
36	8400	8440	8480	8520	8561	8601	8642	8682	8723	8764
37	8805	8846	8887	8928	8969	9010	9052	9093	9135	9177
38	9219	9260	9302	9344	9387	9429	9471	9514	9556	9599
39	9642	9684	9727	9770	9813	9857	9900	9943	9987	10030
40	10074	10118	10162	10206	10250	10294	10338	10382	10427	10471
41	10516	10560	10605	10650	10695	10740	10785	10830	10876	10921
42	10967	11012	11058	11104	11150	11196	11242	11288	11334	11380
43	11427	11473	11520	11567	11614	11660	11707	11754	11802	11849
44	11896	11944	11991	12039	12087	12134	12182	12230	12278	12327
45	12375	12423	12472	12520	12569	12618	12667	12716	12765	12814
46	12863	12912	12962	13011	13061	13111	13160	13210	13260	13310
47	13360	13410	13461	13511	13562	13613	13662	13713	13764	13815
48	13867	13918	13969	14020	14072	14123	14175	14227	14279	14330
49	14382	14435	14487	14539	14591	14644	14696	14749	14802	14855
50	14907	14960	15014	15067	15120	15173	15227	15280	15334	15388
51	15442	15496	15550	15604	15658	15712	15767	15821	15876	15931
52	15985	16040	16095	16150	16205	16260	16316	16371	16427	16482
53	16538	16594	16650	16706	16761	16817	16874	16930	16987	17043
54	17100	17157	17214	17270	17328	17385	17441	17499	17556	17613
55	17671	17729	17787	17845	17903	17961	18019	18077	18135	18193
56	18252	18310	18369	18428	18487	18545	18604	18663	18723	18782
57	18842	18901	18961	19021	19080	19140	19200	19260	19320	19380
58	19441	19501	19562	19622	19683	19744	19804	19865	19926	19988
59	20049	20110	20172	20233	20295	20357	20418	20480	20542	20604
60	20667	20729	20791	20854	20916	20979	21041	21104	21167	21230


5°
10°
15°
20°
25°
60
55
50
45
40
35
30
25
20
15
10
5
0
30°
34°
a
Centre line, and levels.
SIDE-SLOPES 1¼ to 1.
ROADWAY 18 Ft.
For Excavation.

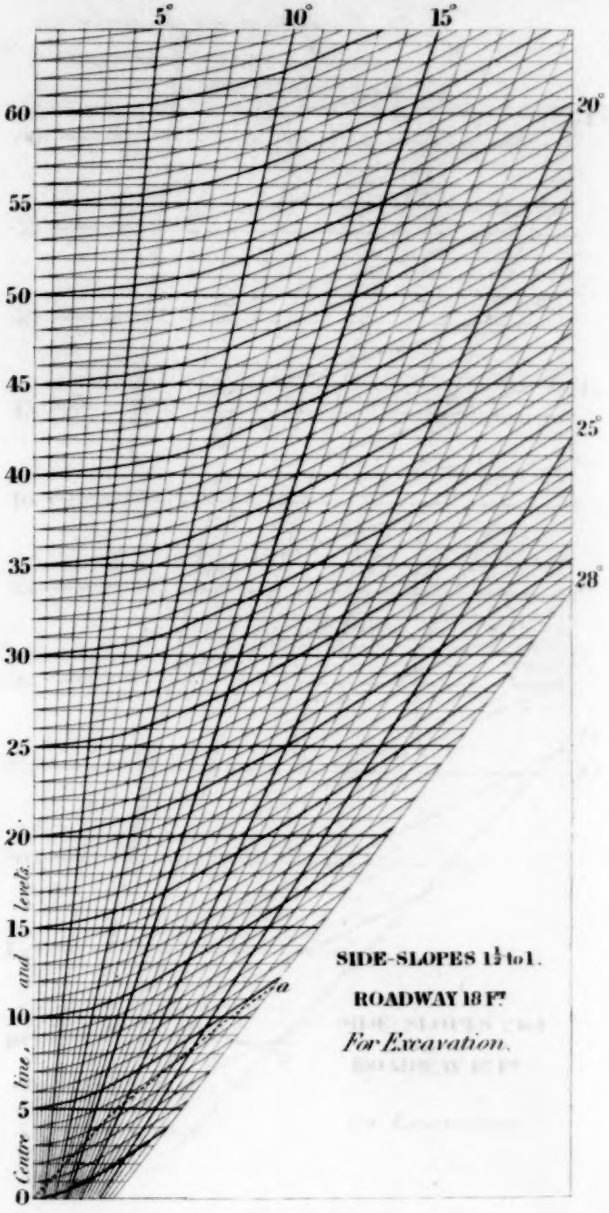

5°
10°
15°
20°
25°
28°
60
55
50
45
40
35
30
25
20
15
10
5
0
Centre line, and levels.
SIDE-SLOPES 1½ to 1.
ROADWAY 18 Ft.
For Excavation.

TABLE 5.—LEVEL CUTTINGS.

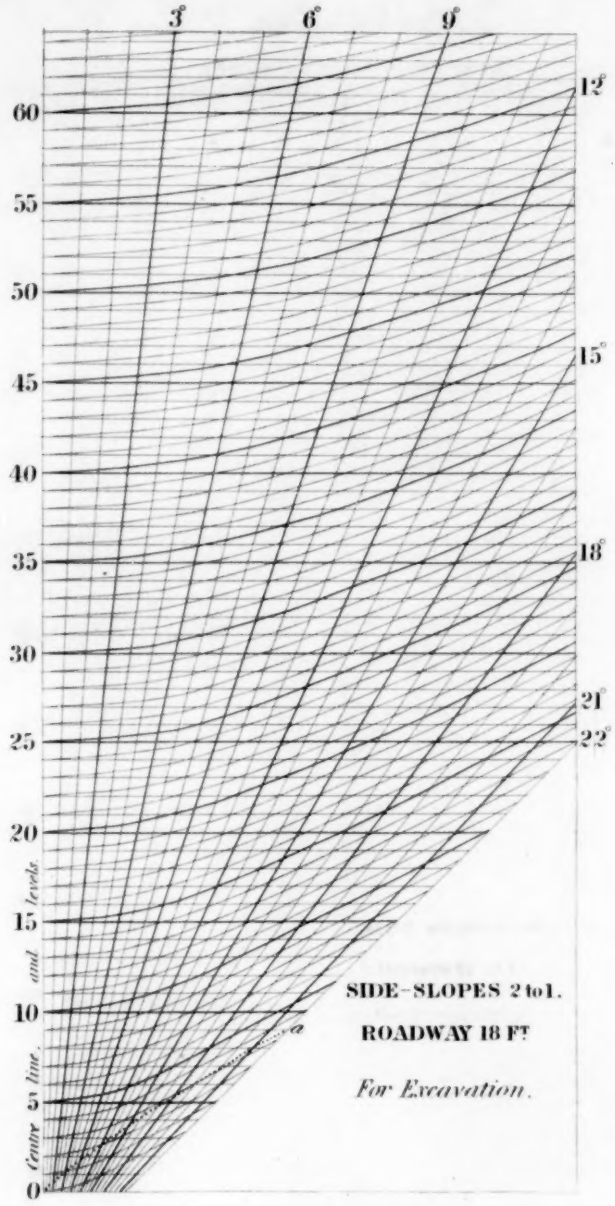
Roadway 18 *feet wide, side-slopes* 1½ *to* 1.

Depth in ft.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.
0		6·72	13·6	20·5	27·6	34·7	42.0	49·4	56·9	64·5
1	72·2	80·1	88·0	96·1	104·2	112·5	120·9	129·4	138·0	146·7
2	155·5	164·5	173·5	182·7	191·9	201·3	210·8	220·4	230·1	240·0
3	249·9	260·0	270·1	280·4	290·8	301·3	311·9	322·6	333·4	344·5
4	355·5	366·7	378·0	389·4	400·9	412·5	424·2	436·0	448·0	460·0
5	472·2	484·5	496·9	509·4	522·0	534·7	547·6	560·5	573·6	586·7
6	600·0	613·4	626·9	640·5	654·2	668·1	682·0	696·1	710·2	724·5
7	738·9	753·4	768·0	782·7	797·6	812·5	827·6	842·7	858·0	873·4
8	888·9	904·5	920·2	936·1	952·0	968·1	984·2	1001	1017	1033
9	1050	1067	1084	1101	1118	1135	1152	1169	1187	1205
10	1222	1241	1258	1276	1294	1313	1331	1349	1368	1387
11	1406	1425	1444	1463	1482	1501	1521	1541	1560	1580
12	1600	1620	1640	1661	1681	1701	1722	1743	1964	1785
13	1806	1827	1848	1869	1891	1913	1934	1956	1978	2000
14	2022	2045	2067	2089	2112	2135	2158	2181	2204	2227
15	2250	2273	2297	2321	2344	2368	2392	2416	2440	2465
16	2489	2513	2538	2563	2588	2613	2638	2663	2688	2713
17	2739	2765	2790	2816	2842	2868	2894	2921	2947	2973
18	3000	3027	3054	3081	3108	3135	3162	3189	3217	3245
19	3272	3300	3328	3356	3384	3413	3441	3469	3498	3527
20	3556	3585	3614	3643	3672	3701	3731	3761	3790	3820
21	3850	3880	3910	3941	3971	4001	4032	4063	4094	4125
22	4156	4187	4218	4249	4281	4313	4344	4376	4408	4440
23	4472	4505	4537	4569	4602	4635	4668	4701	4734	4767
24	4800	4833	4867	4901	4934	4968	5002	5036	5070	5105
25	5139	5173	5208	5243	5278	5313	5348	5383	5418	5453
26	5489	5525	5560	5596	5632	5668	5704	5741	5777	5814
27	5850	5887	5924	5961	5998	6035	6072	6109	6147	6185
28	6222	6260	6298	6336	6374	6413	6451	6489	6528	6567
29	6606	6645	6684	6723	6762	6801	6841	6881	6920	6960
30	7000	7040	7080	7121	7161	7201	7242	7283	7324	7365
31	7406	7447	7488	7529	7571	7613	7654	7696	7738	7780
32	7822	7865	7907	7949	7992	8035	8078	8121	8164	8207
33	8250	8293	8337	8381	8424	8468	8512	8556	8600	8645
34	8689	8733	8778	8823	8868	8913	8958	9003	9048	9093
35	9139	9185	9230	9276	9322	9368	9414	9461	9507	9553
36	9600	9647	9694	9741	9788	9835	9882	9929	9977	10025
37	10072	10120	10168	10216	10264	10313	10361	10409	10458	10507
38	10556	10605	10654	10703	10752	10801	10851	10901	10950	11000
39	11050	11100	11150	11200	11251	11301	11352	11403	11454	11505
40	11556	11607	11658	11709	11761	11813	11864	11916	11968	12020
41	12072	12125	12177	12229	12282	12335	12388	12441	12494	12547
42	12600	12653	12707	12761	12814	12868	12922	12776	13030	13085
43	13139	13193	13248	13303	13358	13413	13468	13523	13578	13633
44	13689	13745	13800	13856	13912	13968	14024	14081	14137	14193
45	14250	14307	14364	14421	14478	14535	14592	14649	14707	14765
46	14822	14880	14938	14996	15054	15113	15171	15229	15288	15347
47	15406	15465	15524	15583	15642	15701	15761	15821	15880	15940
48	16000	16060	16120	16181	16241	16301	16362	16123	16184	16545
49	16606	16667	16728	16789	16851	16913	16974	17036	17098	17160
50	17222	17285	17347	17409	17472	17535	17598	17661	17724	17787
51	17850	17913	17977	18041	18104	18168	18232	18296	18360	18425
52	18489	18553	18618	18683	18748	18813	18878	18943	19008	19073
53	19139	19205	19270	19336	19402	19468	19534	19601	19667	19733
54	19800	19867	19934	20000	20068	20135	20202	20269	20337	20405
55	20472	20540	20608	20676	20744	20813	20881	20949	21018	21087
56	21156	21225	21294	21363	21432	21501	21571	21641	21710	21780
57	21850	21920	21990	22061	22131	22201	22272	22343	22414	22485
58	22556	22627	22698	22769	22841	22913	22984	23056	23128	23200
59	23272	23345	23417	23489	23562	23635	23708	23781	23854	23927
60	24000	24073	24147	24221	24294	24368	24442	24516	24590	24665

Table 6.—LEVEL CUTTINGS.

Roadway 18 *feet wide, side-slopes* 2 *to* 1.

Depth in ft.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.
0		6·74	13·6	20·7	27·9	35·2	42·7	50·3	58·1	66·0
1	74·1	82·3	90·7	99·2	107·9	116·7	125·6	134·7	144·0	153·4
2	163·0	172·7	182·5	192·5	202·7	213·0	223·4	234·0	244·7	255·6
3	266·7	277·9	289·2	300·7	312·3	324·1	336·0	348·1	360·3	372·7
4	385·2	369·9	410·7	423·6	436·7	450·0	463·4	477·0	490.7	504.5
5	518·5	532·7	547·0	561·4	576·0	590·7	605·6	620·7	635·9	651·2
6	666·7	682·3	698·1	714·0	730·1	746·3	762·7	779·2	795·9	812·7
7	829·6	846·7	864·0	881·4	899·0	916·7	934·5	952·5	970·7	989·0
8	1007	1026	1045	1064	1083	1102	1121	1141	1160	1180
9	1200	1220	1240	1261	1281	1302	1323	1344	1365	1386
10	1407	1429	1451	1473	1495	1517	1539	1561	1584	1607
11	1630	1673	1676	1699	1723	1746	1770	1794	1818	1842
12	1867	1891	1916	1941	1966	1991	2016	2041	2067	2093
13	2119	2143	2171	2197	2223	2250	2277	2304	2331	2358
14	2385	2413	2440	2468	2496	2524	2552	2581	2609	2638
15	2667	2696	2725	2754	2783	2813	2843	2873	2903	2933
16	2963	2993	3024	3055	3086	3117	3148	3179	3211	3242
17	3274	3306	3338	3370	3403	3435	3468	3501	3534	3567
18	3600	3633	3667	3701	3735	3769	3803	3837	3871	3906
19	3941	3976	4011	4046	4081	4117	4152	4188	4224	4260
20	4296	4333	4369	4406	4443	4480	4517	4554	4591	4629
21	4667	4705	4743	4781	4819	4857	4896	4935	4974	5013
22	5052	5091	5131	5170	5210	5250	5290	5330	5371	5411
23	5452	5493	5534	5575	5616	5657	5699	5741	5783	5825
24	5867	5909	5951	5994	6037	6080	6123	6166	6209	6253
25	6296	6340	6384	6428	6472	6517	6561	6606	6651	6696
26	6741	6786	6831	6876	6923	6969	7015	7061	7107	7153
27	7200	7247	7294	7341	7388	7435	7483	7530	7578	7626
28	7674	7722	7771	7819	7868	7917	7966	8015	8064	8113
29	8163	8213	8263	8313	8363	8413	8463	8514	8565	8616
30	8667	8718	8769	8821	8872	8924	8976	9028	9080	9133
31	9185	9238	9291	9344	9397	9450	9503	9557	9611	9665
32	9719	9773	9827	9881	9936	9991	10046	10101	10156	10211
33	10267	10322	10378	10434	10490	10546	10603	10659	10716	10773
34	10830	10887	10944	11001	11059	11117	11175	11233	11291	11349
35	11407	11466	11525	11584	11643	11702	11761	11821	11880	11940
36	12000	12060	12120	12181	12241	12302	12363	12424	12485	12546
37	12607	12669	12731	12793	12855	12917	12979	13041	13104	13167
38	13230	13293	13356	13419	13482	13546	13610	13674	13738	13802
39	13867	13931	13996	14061	14126	14191	14256	14321	14387	14453
40	14519	14585	14651	14717	14783	14850	14917	14984	15051	15118
41	15185	15253	15320	15388	15456	15524	15592	15661	15729	15798
42	15867	15936	16005	16074	16143	16213	16283	16353	16423	16493
43	16563	16633	16704	16775	16846	16917	16988	17059	17131	17202
44	17274	17346	17418	17490	17563	17635	17708	17781	17854	17927
45	18000	18073	18147	18221	18295	18369	18443	18517	18591	18666
46	18741	18816	18891	18966	19041	19117	19192	19268	19344	19420
47	19496	19573	19649	19726	19803	19880	19957	20034	20111	20189
48	20267	20345	20423	20501	20579	20657	20736	20815	20894	20973
49	21052	21131	21211	21290	21370	21450	21530	21610	21691	21771
50	21852	21933	22014	22095	22176	22257	22339	22421	22503	22585
51	22667	22749	22831	22914	22997	23080	23163	23246	23329	23413
52	23496	23580	23664	23748	23832	23917	24001	24086	24171	24256
53	24341	24426	24511	24597	24683	24769	24855	24941	25027	25113
54	25200	25287	25374	25461	25548	25635	25723	25810	25898	25986
55	26074	26162	26251	26339	26428	26517	26606	26695	26784	26873
56	26963	27053	27143	27233	27323	27413	27503	27594	27685	27776
57	27867	27958	28049	28141	28232	28324	28416	28508	28600	28693
58	28785	28878	28971	29064	29157	29250	29343	29437	29531	29625
59	29519	29813	29907	30001	30096	30191	30286	30381	30476	30571
60	30767	30762	30858	30954	31050	31146	31242	31339	31436	31533


3°
6°
9°
12°
15°
18°
21°
22°
60
55
50
45
40
35
30
25
20
15
10
5
0
Centre line. and levels.
SIDE-SLOPES 2 to 1.
ROADWAY 18 Ft
For Excavation.

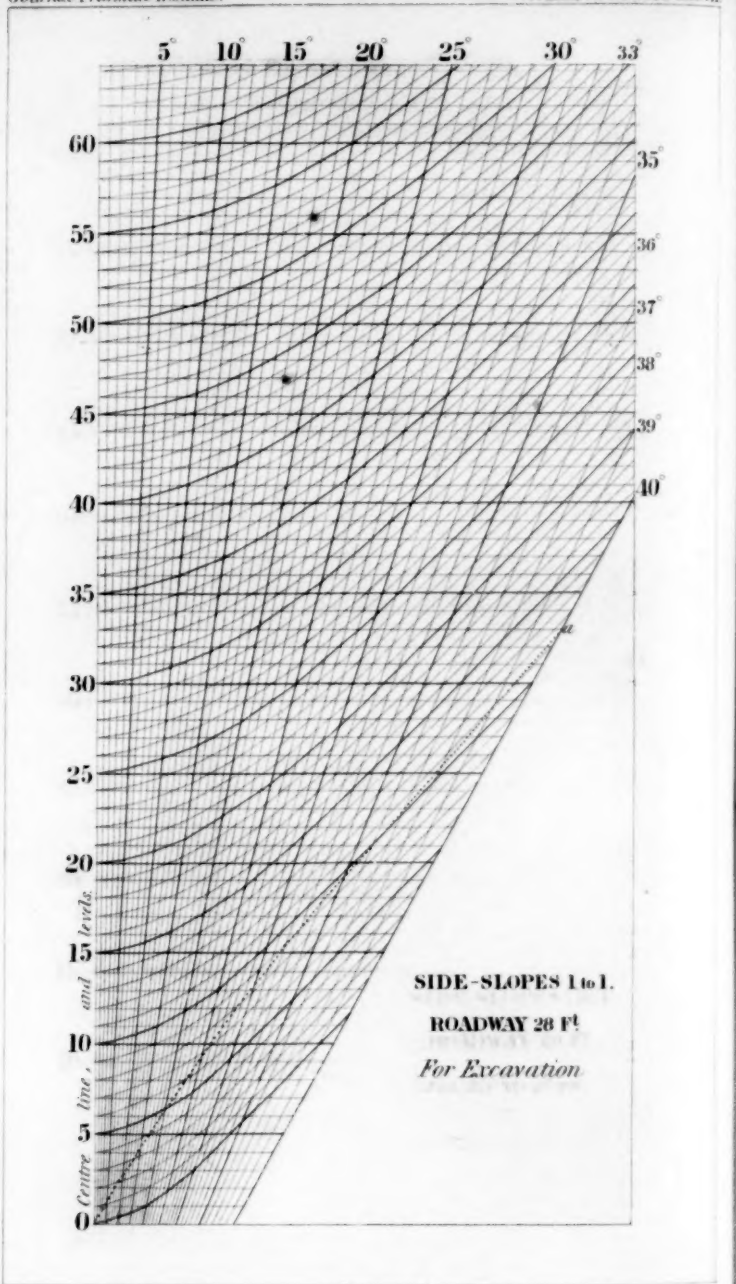

5° 10° 15° 20° 25° 30° 33°
60
55
50
45
40
35
30
25
20
15
10
5
0
35°
36°
37°
38°
39°
40°
a
Centre line, and levels.
SIDE-SLOPES 1 to 1.
ROADWAY 28 Ft.
For Excavation

TABLE 7.—LEVEL CUTTINGS.

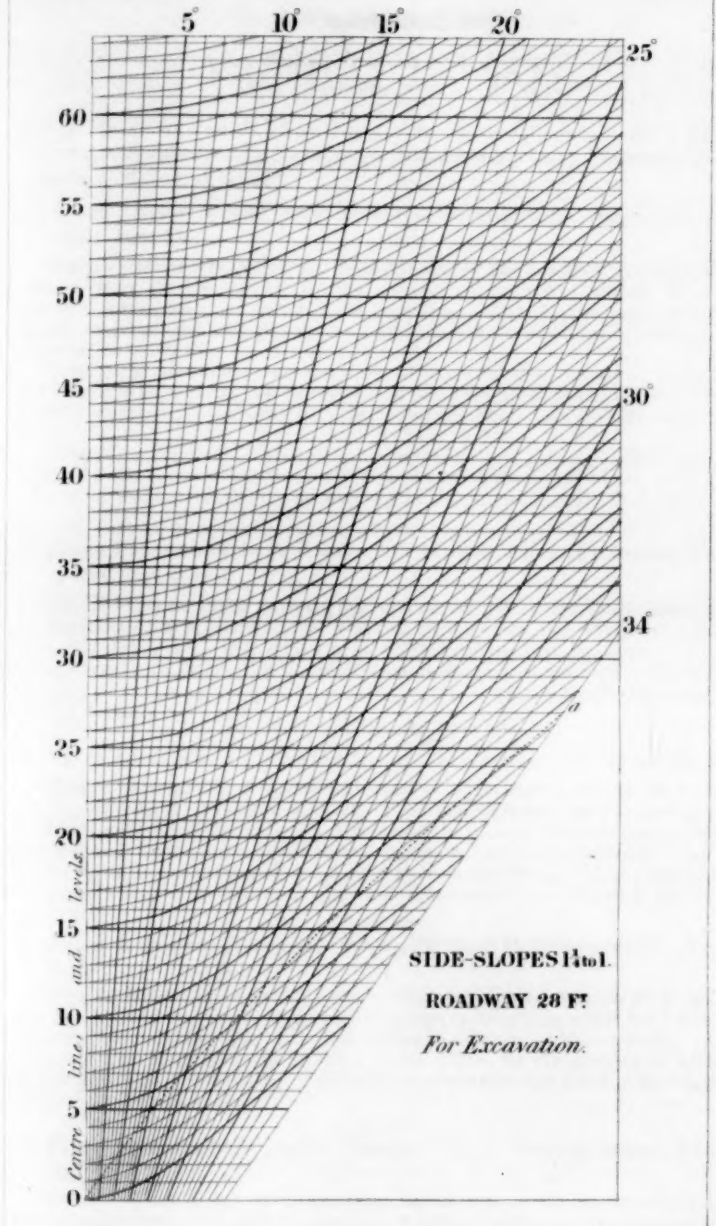
Roadway 28 *feet wide, side-slopes* 1 *to* 1.

Depth in ft.	·0	1.	·2	·3	·4	·5	·6	·7	·8	·9
	cu. yds	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.
0		10·4	20·9	31·4	42·1	52·8	63·6	74·4	85·3	96·3
1	107·4	118·6	129·8	141·1	152·4	163.9	175·4	187·0	198·7	210·4
2	222·2	234·1	246·1	258·1	270·2	282·4	294.7	307·0	319·4	331·9
3	344·4	357·1	369·8	382·6	395·4	408·3	421·3	434·4	447·6	460·8
4	474·1	487·4	500·9	514·4	528·0	541·7	555·4	569·2	583·1	597·1
5	611·1	625·2	639·4	653·7	668·0	682·4	696·9	711·4	726·1	740·8
6	755·6	770·4	785·4	800·4	815·5	830·6	845·8	861·1	876·5	891·9
7	907·5	923·0	938·7	954·5	970·3	986·2	1002	1018	1034	1050
8	1067	1083	1099	1116	1132	1149	1166	1182	1199	1216
9	1233	1250	1267	1285	1302	1319	1337	1354	1372	1390
10	1407	1425	1443	1461	1479	1497	1515	1534	1552	1570
11	1589	1607	1626	1645	1664	1682	1701	1720	1739	1759
12	1778	1797	1816	1836	1855	1875	1895	1914	1934	1954
13	1974	1994	2014	2034	2055	2075	2095	2116	2136	2157
14	2178	2199	2219	2240	2261	2282	2304	2325	2346	2367
15	2389	2410	2432	2454	2475	2497	2519	2541	2563	2585
16	2607	2630	2652	2674	2697	2719	2742	2765	2788	2810
17	2833	2856	2879	2903	2926	2949	2972	2996	3019	3043
18	3067	3090	3114	3138	3162	3186	3210	3234	3259	3283
19	3307	3332	3356	3381	3406	3431	3455	3480	3505	3530
20	3556	3581	3606	3631	3657	3682	3708	3734	3759	3785
21	3811	3837	3863	3889	3915	3942	3968	3994	4021	4047
22	4074	4101	4128	4154	4181	4208	4235	4263	4290	4317
23	4344	4372	4399	4427	4455	4482	4510	4538	4566	4594
24	4622	4650	4679	4707	4735	4764	4792	4821	4850	4879
25	4907	4936	4965	4994	5024	5053	5082	5111	5141	5170
26	5200	5230	5259	5289	5319	5349	5379	5409	5439	5470
27	5500	5530	5561	5591	5622	5653	5684	5714	5745	5776
28	5807	5839	5870	5901	5932	5964	5995	6027	6059	6090
29	6122	6154	6186	6218	6250	6282	6315	6347	6379	6412
30	6444	6477	6510	6543	6575	6608	6641	6674	6708	6741
31	6774	6807	6841	6874	6908	6942	6975	7009	7043	7077
32	7111	7145	7179	7214	7248	7282	7317	7351	7386	7421
33	7456	7490	7525	7560	7595	7631	7666	7701	7736	7772
34	7807	7843	7879	7914	7950	7986	8022	8058	8094	8130
35	8167	8203	8239	8276	8312	8349	8386	8423	8459	8496
36	8533	8570	8608	8645	8682	8719	8757	8794	8832	8870
37	8907	8945	8983	9021	9059	9097	9135	9174	9212	9250
38	9289	9327	9366	9405	9444	9482	9521	9560	9599	9639
39	9678	9717	9756	9796	9835	9875	9915	9954	9994	10034
40	10074	10114	10154	10194	10235	10275	10315	10356	10396	10437
41	10478	10519	10559	10600	10641	10682	10724	10765	10806	10847
42	10889	10930	10972	11014	11055	11097	11139	11181	11223	11265
43	11307	11350	11392	11434	11477	11519	11562	11605	11648	11690
44	11733	11777	11819	11863	11906	11949	11992	12036	12079	12123
45	12167	12210	12254	12298	12342	12386	12430	12474	12519	12563
46	12607	12652	12696	12741	12786	12831	12875	12920	12965	13010
47	13056	13101	13146	13191	13237	13282	13328	13374	13419	13465
48	13511	13557	13603	13649	13695	13742	13788	13834	13881	13927
49	13974	14021	14068	14114	14161	14208	14255	14303	14350	14397
50	14444	14492	14539	14587	14635	14682	14730	14778	14826	14874
51	14922	14970	15019	15067	15115	15164	15212	15261	15310	15359
52	15407	15456	15505	15554	15604	15653	15702	15751	15801	15850
53	15900	15950	15999	16049	16099	16149	16199	16249	16299	16350
54	16400	16450	16501	16551	16602	16653	16704	16754	16805	16856
55	16907	16959	17010	17061	17112	17164	17215	17267	17319	17370
56	17422	17474	17526	17578	17630	17682	17735	17787	17839	17892
57	17944	17997	18050	18103	18155	18208	18261	18314	18368	18421
58	18474	18527	18581	18634	18688	18742	18795	18849	18903	18957
59	19011	19065	19119	19174	19228	19282	19337	19391	19446	19501
60	19556	19610	19665	19720	19775	19831	19886	19941	19996	20052

TABLE 8.—LEVEL CUTTINGS.

Roadway 28 feet wide, side-slopes 1¼ to 1.

Depth in ft.	0	·1	·2	·3	·4	·5	·6	·7	·8	9.
	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.	cu. yds.
0		10·4	20·9	31·5	42·2	53·0	63·9	74·9	85·9	97·1
1	108·3	119·7	131·1	142·7	154·3	166·0	177·8	189·7	201·7	213·8
2	225·9	238·2	250·6	263·0	275·6	288·2	301·0	313·8	326·7	339·8
3	352·8	366·0	379·3	392·7	406·2	419·8	433·4	447·2	461·1	475·0
4	488·9	503·0	517·3	531·6	546·0	560·5	575·1	589·8	604·6	619·5
5	634·4	649·5	664·7	679·9	695.3	710·7	726·2	741·9	757·6	773·4
6	788·9	804·9	821·0	837·2	853·4	869·8	886·3	902·8	919·5	936·2
7	952·8	969·8	986·8	1004	1021	1038	1056	1073	1091	1109
8	1126	1144	1162	1180	1198	1216	1234	1252	1271	1289
9	1308	1327	1346	1365	1384	1403	1422	1442	1461	1481
10	1500	1520	1540	1559	1579	1599	1620	1640	1660	1681
11	1701	1722	1742	1763	1784	1805	1826	1847	1869	1890
12	1911	1933	1954	1976	1998	2020	2042	2064	2086	2109
13	2131	2153	2175	2198	2221	2244	2267	2290	2313	2336
14	2359	2382	2406	2429	2453	2477	2501	2525	2549	2573
15	2597	2622	2646	2671	2695	2720	2745	2770	2795	2820
16	2844	2870	2895	2921	2946	2971	2998	3023	3049	3075
17	3101	3127	3153	3180	3206	3233	3259	3286	3313	3340
18	3367	3393	3421	3448	3475	3503	3531	3558	3586	3614
19	3641	3669	3698	3726	3754	3782	3811	3840	3868	3897
20	3925	3954	3984	4013	4042	4071	4101	4130	4160	4189
21	4219	4249	4279	4309	4339	4369	4399	4430	4460	4491
22	4522	4553	4584	4615	4646	4677	4708	4740	4771	4803
23	4834	4866	4898	4930	4962	4994	5026	5058	5091	5123
24	5156	5188	5221	5254	5287	5320	5353	5386	5419	5453
25	5486	5520	5553	5587	5621	5655	5689	5723	5757	5791
26	5826	5860	5895	5930	5964	5999	6034	6069	6104	6140
27	6175	6210	6246	6282	6317	6353	6389	6425	6461	6497
28	6533	6570	6606	6643	6679	6716	6753	6790	6827	6864
29	6901	6938	6976	7013	7051	7088	7126	7164	7202	7240
30	7278	7316	7354	7393	7431	7470	7508	7547	7586	7625
31	7664	7703	7742	7781	7821	7860	7900	7940	7979	8019
32	8059	8099	8139	8180	8220	8260	8301	8341	8382	8423
33	8464	8505	8546	8587	8628	8669	8711	8752	8794	8836
34	8878	8920	8962	9004	9046	9088	9131	9173	9216	9258
35	9301	9344	9387	9430	9473	9516	9559	9603	9646	9689
36	9733	9777	9821	9865	9909	9953	9997	10041	10086	10130
37	10175	10220	10264	10309	10354	10399	10445	10490	10535	10580
38	10626	10672	10717	10763	10809	10855	10901	10946	10993	11040
39	11086	11133	11179	11226	11273	11320	11367	11414	11461	11508
40	11556	11603	11651	11698	11746	11794	11842	11890	11938	11986
41	12035	12083	12131	12180	12228	12277	12326	12375	12424	12473
42	12522	12572	12621	12671	12720	12770	12819	12869	12919	12969
43	13019	13069	13120	13171	13221	13272	13322	13373	13424	13475
44	13526	13577	13628	13680	13731	13782	13834	13886	13938	13990
45	14042	14094	14146	14198	14251	14303	14356	14408	14461	14514
46	14567	14620	14673	14726	14779	14833	14886	14940	14993	15047
47	15101	15155	15209	15263	15317	15372	15426	15480	15535	15590
48	15644	15699	15754	15810	15864	15920	15975	16030	16086	16142
49	16197	16253	16309	16365	16421	16477	16533	16590	16646	16703
50	16759	16816	16873	16930	16987	17044	17101	17158	17216	17273
51	17331	17388	17446	17504	17562	17620	17678	17736	17794	17873
52	17911	17970	18028	18087	18146	18205	18264	18323	18382	18442
53	18500	18560	18620	18680	18739	18799	18859	18919	18980	19040
54	19100	19160	19220	19282	19342	19403	19464	19525	19586	19647
55	19708	19770	19831	19893	19954	20016	20078	20140	20202	20264
56	20326	20388	20451	20513	20576	20639	20701	20764	20827	20890
57	20953	21016	21079	21143	21206	21270	21333	21397	21461	21525
58	21589	21653	21717	21782	21846	21911	21975	22040	22104	22169
59	22234	22299	22364	22430	22495	22561	22626	22692	22758	22823
60	22889	22955	23021	23087	23153	23220	23286	23353	23419	23486


5°
10°
15°
20°
25°
30°
34°
60
55
50
45
40
35
30
25
20
15
10
5
0
Centre line, and levels
a
SIDE-SLOPES 1½ to 1.
ROADWAY 28 Ft
For Excavation.

AMERICAN PATENTS.

List of American Patents which issued from June 17, to July 8, 1851, (inclusive,) with Exemplifications by CHARLES M. KELLER, *late Chief Examiner of Patents in the U. S. Patent Office.*

31. For an *Improvement in Brick Machines;* Mahlon Gregg, Philadelphia, Pennsylvania, June 17.

Claim.—"Having described my improvements in the machine for making bricks, what I claim therein as new is, the rotating mould-wheel, constructed as herein described, with a series of moulds in its periphery, and an annular plane outside of the moulds, and furnished with pistons, arranged as herein described, for the purpose of discharging the bricks from the moulds, as set forth.

"I also claim the mode herein described, of changing the positions of the pistons, by means of the bar attached to the horizontal presser, with its block and plate, which are made to impinge upon the vertical plates, which are attached to the pistons for that purpose.

"I also claim the combination of the hopper, horizontal presser, vertical presser, and hook rod, with the transverse horizontal lever, and with the mould wheel; the whole being constructed and arranged in the manner and for the purposes herein described."

32. For an *Improvement in the Construction of Dies;* Hiram W. Hayden, Waterbury, Connecticut, June 17.

Claim.—"I do not claim to be the first to construct a die with a lined surface, to deaden the metallic surface operated on; but what I do claim as new, and of my own invention, is the application of a die with a lined or corrugated surface, with the figure or pattern cut, or countersunk, so that the lined surface deadens the plate of polished metal, and leaves the polished surface of the figure untouched, for producing ornamental designs on polished metallic surfaces."

33. For an *Improvement in Cooking Stoves;* Elias Young, Cincinnati, Ohio, June 17.

Claim.—"Having thus described the nature of my invention, what I claim therein as new, is, the cold air passages, substantially as here arranged, to wit: having each an external aperture near their upper part on each side, beneath which projects a plate which carries the air to the centre of the stove, whence, by a second plate beneath the middle of the passage, it is again deflected to the outer ends of the passage, (thus counterbalancing the cooling effects at its entrance,) whence it is distributed in hot blasts to the fire."

34. For an *Improvement in Wash Boards;* William T. Barnes, Buffalo, New York, June 17.

Claim.—"What I claim, is, 1st, fastening cloth (or its equivalent) on the board, to prevent fine fabrics from slipping and from being torn or rubbed too much, but I do not claim lining the grooved wash board with india rubber or other equivalent material.

"2nd, I claim hinging the wash board to the frame, for the purpose of holding the clothes while being washed, and at the same time allowing the board to be turned over, substantially as herein set forth."

35. For an *Improvement in Augers;* Ransom Cook, of Saratoga Springs, New York, June 17.

Claim.—"What I claim as my invention, is, the form of the lips or cutting edges of boring implements, as illustrated in figures 1, 2, and 4, that is, such lip commencing at the screw or centre point, and running nearly at right angles thereto, until about half way from the centre to the outer part of the boring implement, when it assumes a curve upwards, or towards the handle end of the instrument, which curve is continued until it is nearly semi-circular, or until it turns within the periphery of the auger or bit, the curved edges being also under-cut or back-sloped, but without being confined to any particular angle of such back-sloping, or under-cutting: all as herein before set forth."

36. For *Improvements in Knitting Machines;* Rufus Ellis, Northampton, Massachusetts, Assignor to William M. Chase, of Boston, Massachusetts, June 17.

"The machine, as improved, is not what is usually termed, a stocking loom, but is more properly named a knitting machine, for the reason that it forms each stitch of the work in regular succession, and not a number of stitches at once, as does the stocking loom."

Claim.—"What I claim as my improvement, is the arrangement of the needles in the *plane of the endless* belt, instead of at right angles to it, in combination with the arrangement of the driving pinion, and the projecting joints of the links of the belt, *on the outside of the belt*, the belt being supported, and the whole being applied to the stitch-hook, yarn guide, and presser, and made to operate together, and with the work hanging *on the inside* of the belt, substantially as herein before specified."

---

37. For an *Improved Connexion of Telescopic Masts and Spars;* Charles F. Brown, Warren, Rhode Island, June 17.

"The nature of my invention consists in connecting the tubes together and adjusting them by means of a screwed rod or rods, running longitudinally through them; each rod being secured in one tube, so as to be incapable of turning, and passing through a nut or nuts in one or more of the other tubes; the whole series of tubes being adjustable, one within another, by turniug those in which are the nuts, so as to move the nuts along the screw on the rod, and each tube being capable of being secured by set screws, at various points of its length."

Claim.—"What I claim as my invention, is connecting and adjusting the several joints of masts, yards, and all spars constructed of telescopic tubes, or tubes fitting one within another, by means of a screwed rod or screwed rods, nuts, and female screws, and set screws, or their equivalents; the whole being inserted in and secured or attached to the tubes, and operating in the manner substantially as herein set forth."

---

38. For an *Improvement in Machines for Dressing Shingles;* Seymour Carver, Geneva, Illinois, June 17.

Claim.—"What I claim as my invention, is the arrangement of the head block, with the springs, cams, rollers, and stops, for the purpose of passing the shingles between and out from the cutting cylinders, in combination with the arrangement for depressing the upper cylinder while in motion, for the purpose of giving a taper to the shingle; the whole combined and arranged substantially as set forth in the above specification."

---

39. For an *Improvement in Running Gear of Locomotives;* George S. Griggs, Roxbury, Massachusetts, June 17.

Claim.—"What I claim as my invention, is the combination of the bent levers, the connexion rods, and tractile bar or spring, or other equivalent contrivance or contrivances, with the main frame (or its housings), and the boxes or pedestals of the journals of the driving wheels, and for the purpose substantially as hereinbefore specified."

---

40. For an *Improvement in Ventilators;* Thatcher C. Hatch, South Braintree, Massachusetts, June 17.

"My new ventilator is so arranged that from whatever quarter the wind blows, none can blow down the chimney, or whatever other orifice the ventilator may be attached to, but on the contrary, the draft is increased, while at the same time it effectually prevents all rain, &c., from entering."

Claim.—"Having thus described my improvements in ventilators, I shall state my claim as follows:

"What I claim as my invention, is a ventilator as herein above described, composed of two series or sets of curved slats, arranged one within the other, and running from the edge of the flue or other orifice, to a small circle or plate over the centre of the same; the whole forming a conical or globe-shaped ventilator, the spaces between the several outer slats being protected by the inner slats, having spaces or apertures between the two sets of slats, the only openings to said apertures being in an oblique or sideways direction—all as herein above specified and set forth."

41. For an *Improvement in Regulators for the Pen Beam in Ruling Machines;* W. O. Hickok, Harrisburg, Pennsylvania, June 17.

Claim.—"I do not claim to be the inventor of the flexible, hooked regulator, attached to the pen beam, as heretofore constructed; but what I do claim as my invention, are, 1st, I claim the pieces in combination with the hinge joints arranged and combined substantially and for the purpose as herein described.

2nd, "I claim the sliding piece, the bearings, and the finger wheel, in combination with the pieces uniting by hinge joints, or in any other manner substantially the same, using, in the construction of the whole machine, any material adapted to the purpose of forming, as herein described, a pen beam regulator, for ruling machines."

---

42. For *Improvements in Revolving Boilers;* Charles Anderson, Warren, Pennsylvania, June 17.

"My improvement consists in lining the inside of the heating surface of the boiler with wire cloth gauze, or any perforated or pervious metal work, for the purpose of gathering up the water during the motion of the boiler, and by giving a great evaporating surface, converting it quickly into steam."

Claim.—"Having thus fully described my invention, I will proceed to state what I claim as new:

"I claim lining the inside of that part of a revolving boiler which comes in contact with the fire or heat, with wire gauze, or cloth, or any perforated or pervious metal work, in the manner and for the purpose substantially as herein described."

---

43. For an *Improvement in Ploughs;* John Cooper, (Administrator of Benjamin Giger, deceased,) Sangamon county, Illinois, June 24.

Claim.—"What is claimed as the invention of Benjamin Giger, and as not previously known, is the peculiar form and construction of the standard with its sockets at the upper extremity, and flanches at the lower, and the method of uniting them, so as to form a double machine, capable also of being used for cultivation in its separate parts, as set forth."

"The whole machine, as above described, constitutes "Giger's Corn Planter."

---

44. For *Self-acting Guard Frog,* Charles A. Postley, Spring Garden, Pennsylvania, June 24.

"Letter *a*, surface of the ground; *b b*, the rails; *d d*, steel points to rails; *e e* are levers acting upon the guards *f*1 *f*2, and upon the upright bars or rods 3 3 3; *f*1 *f*2 guards,

Fig 1

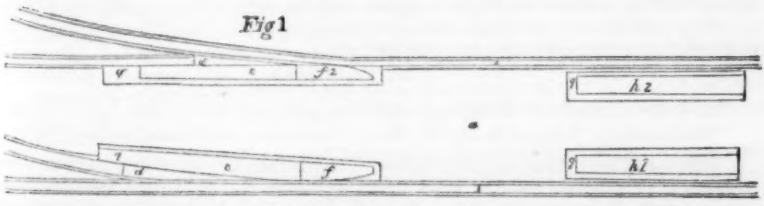
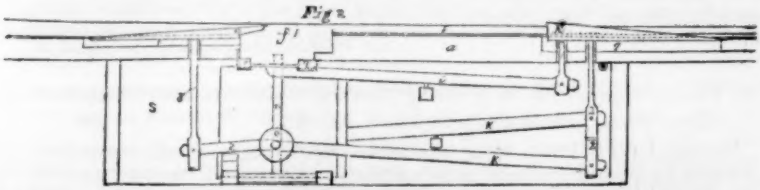


Fig 2



g g g g iron castings, forming a chamber for levers *o e* and h^1 h^2 to work in; h^1 h^2 are also levers, acting upon the upright arms or bars 1 1 and 2 2 of levers *i i* and *k k*; *i i*,

lifting levers; *k k*, catch levers; *l l* are also catch levers; fig. 1 1, 2 2, and 3 3, in the various drawings, are upright bars or rods; *m m* are upright levers, acting directly upon and being attached to the catches *n n*, by means of the connecting rods *t t*; *n n*, vertical catches: *o o*, weight acting upon the vertical catches *n n*, by arm or rod *p*; *q*, catch in the guard; *r r*, guard lever bars, or oscillating frame; *S*, vault for the levers to work in.

"The nature of my invention consists in placing two levers h^1 h^2, inside the track, and at such a distance from the rails that the flanches of the wheels of the engine and cars shall pass freely along the road, without touching them; one end of said levers being raised higher than the rails, whilst the other is depressed, both sets of levers working upon the upright arms of levers *k k*, as fulcrums; these levers are acted upon by shifting cams or wheels attached to the locomotive."

Claim.—"What I claim as my invention, is the combination of the rising and falling guards, f^1 f^2, with the levers, *e e*, and h^1 h^2, by means of an arrangement of levers, connecting rods, etc., subtantially such as herein specified, and acting in the manner and to produce the results herein set forth."

---

45. For *Improvements in Knitting Machines;* John Pepper, Assignor to Crane, Pepper, & Crane, Portsmouth, New Hampshire, June 24.

Claim.—"What I claim as my invention, 1st, is a sinker to be used in machines for knitting, so constructed as to form the loops upon the needles used in knitting two separate fabrics at the same time and at one operation; and of sufficient weight to draw the requisite quantity of yarn from the supply, to form the loops required.

"2d, Is a slur to be used in knitting machines, so constructed as to let each sinker drop to the falling bar, and draw the requisite quantity of yarn from the supply, to form the loop or loops, between the needles, before it allows the succeeding sinker to drop and act upon the yarn.

"3d, Is a falling bar, so constructed that the slurs and slur boxes traverse upon it, instead of traversing a separate bar.

"4th, Is the combination of the sinkers, stop bars, combs, and needles that traverse, so arranged as to knit two separate fabrics at the same time, with one and the same set of sinkers and slur.

"5th, I do not intend to limit myself to the precise construction described in the foregoing specification, but to use such forms of construction as will answer the purpose intended."

---

46. For *Machinery for Making Wrought Iron Car Wheels;* Maria Vaughn, (Administratrix of Joseph C. Vaughn, deceased,) Greenbush, New York, June 24.

Claim.—"I claim the machinery and apparatus set forth and described, to wit: the mould, blocks or welders, the hammer or ram, with the wedges thereto attached, and the mandrel, in combination with each other, for the purpose of making wrought iron wheels, substantially as set forth in this specification."

---

47 For an *Improvement in Machines for Splitting Horn and Shell;* Jabez Robins, Boston, Massachusetts, Assignor to Joel R. Morse, Leominster, Massachusetts, June 24.

Claim.—"What I claim as my invention, or improvement, is the cylindrical rotary bed or drum, in combination with the water cistern or trough, and its furnace, and machinery over the drum, for bearing the shell or material down upon it, during its revolution, as specified; the said drum being provided with a roughened or friction curved surface, such as will adhere to the shell, and cause it to move with it and against the knife as described."

---

46. For an *Improvement in Printing Names of Subscribers upon Newspapers, etc.;* Henry Moeser, Pittsburgh, Pennsylvania, June 24.

Claim.—"What I claim as my invention, is the arrangement and construction of a machine for printing names of persons or places, on newspapers and other papers, after the manner substantially as described, viz: of a form containing the column of names to be printed, set up in types, and being brought under the action of a stamp, by means of a slide moving by degrees; together with the application of a slitted plate, allowing the paper

(to be printed) to be pressed down on the line right beneath the slit of the plate, and shielding the paper from the lines adjoining that under action of the stamp, as hereinbefore described."

---

49. For an *Improvement in Lubricating Compounds;* Jacob Selgrath, Pottsville, Pennsylvania, June 24.

Claim.—"Having thus described the mode in which my anti-attrition is compounded and used, what I claim therein as new, is the combination of ingredients herein described, whether the proportions be the same as herein set forth, or varied to any extent that the same may admit of, without changing the peculiar character of the compound as a lubricator."

---

50. For an *Improvement in Cars for Transportation of Coal;* Laurence Myers, Philadelphia, Pennsylvania, June 24.

"The nature of my invention consists in one, two, or more metallic cylinders, which are adjusted in a frame, so as to be guided by it, and which cylinders have flanched rims firmly secured to them, at such points upon the cylinders as will adapt them to the width of the railroad track upon which they are to run, and upon which flanched rims the cylinder and the material contained therein revolve—the material being kept in place whilst the car is in motion, by the centrifugal force, and prevented from falling, or rolling, whilst in the act of stopping or starting, by a partition or partitions in said cylinder."

Claim.—"Having thus fully described my invention, I wish it to be distinctly understood, that I do not claim the use of cylinders for conveying material upon common roads, as this has been done heretofore; but what I do claim as of my invention, is the combination of a partition, or partitions, with a metallic cylinder, or cylinders, provided with flanched rims, as herein described, for the purpose of carrying material in bulk, on rail or other roads, where high velocities are attained, said material being held in place by centrifugal force whilst in motion, and prevented from falling or rolling in the cylinder, by the partition, or partitions, whilst in the act of stopping or starting, as herein fully described and shown, or by any other means essentially the same."

---

51. For an *Improvement in Machinery for Cutting Rattan, &c.;* Sylvanus Sawyer, Templeton, Massachusetts, June 24.

Claim.—"What I claim as my invention is, 1st, the combination of the cutters, as described, with the levers, springs, and cams, or their equivalents, and also handles and links for the purpose of applying said cutters, or scrapers, so as to act upon the stick of rattan, in the manner herein described, and by which they may all be operated simultaneously, substantially in the manner herein described.

"2d, In the process of cutting cane, or rattan, into strands, as described, I claim bending the stick at the point at which the cutter is removing the strand from the surface.

"3d, I claim the combination of the elements which compose each simple section of the cutting apparatus, that is to say, of the cutter and gauge, with the stock and guide and bed roller, or their equivalents, substantially as described, for the purpose of bending the stick and removing the strand therefrom, whether said section is used alone, or is combined with others as described.

"4th, I claim the combination of that part of the machine called the scraper, with the feeding rollers, or their equivalents, and the several sections of the cutting apparatus; said sections being so arranged, in relation to each other, as that the stick, in passing from the one to the other, shall be properly bent; and also, that the several cutters shall act upon different points of its circumference; the whole being arranged and operating, substantially in the manner described and set forth."

---

52. For an *Improvement in Machines for Finishing the Backs of Books;* Charles Starr, City of New York, June 24.

"I do not claim to be the inventor of 'backing books' by means of a roller, as rollers having concave peripheries have been used, which were passed longitudinally over the back. Nor do I claim the construction of the clamps or jaws between which the book is held. Nor do I claim to have invented the use of circular engraved tools, or rollers, for embossing books; but what I do claim, is, 1st, The use, for the purpose described, of a

roller G, of the whole length or part of the length of the back of the book, either plain, for a plain back book, or grooved, for a raised banded book; or having a figure or figures, cut or engraved, or otherwise made upon it, rolling over the back of the book, from side to side, or from the centre to the sides, and having a yielding pressure applied to it by weighted levers, or their equivalents, in the manner substantially as described.

2nd, I claim clamping or holding the book in a swinging book holder, or its equivalent, which hangs on pivots or journals, and is capable of being swung back and forth, so as to cause the back of the book held in it, to describe an arc of a circle, and bring each part of the back to the roller, so that it shall receive an equal pressure all over its surface, substantially as and for the purposes herein set forth.

3d. The gauges sliding upon an inclined bar or bars, that they may be set to form guides for placing both ends of the back of the book at an equal or nearly equal elevation in the clamp, so as to cause each part to receive an uniform pressure, and may be drawn back from the book without dragging or rubbing the surface of the back, in the manner substantially as herein shown."

---

53. For an *Improvement in making Gutta Percha Hollow Ware;* Samuel T. Armstrong, City of New York, June 24.

"My improved process is applicable to the making of all kinds of hollow articles which can be formed in moulds, such as bottles, or articles which may be made hollow, of gutta percha, or gutta percha compounded with other substances."

Claim.—"What I claim as my invention, in the process above described, is the method, substantially as described, of moulding articles of gutta percha, or the compound of gutta percha with other substances, by first making the same in the form of a pipe, and whilst in a partially heated and plastic state, giving to it the form required in a mould by forcing a liquid inside, to expand the gutta percha as described."

---

54. For an *Improvement in Fastening Pedestals to Columns;* Wm. & Wm. H. Lewis, City of New York, June 24.

Claim.—"What we claim as new and of our own invention, is the application of the piece and different shaped lugs on the end of the column, to enter the hole and notches, so that on turning the column, the lugs take the inclined seats to attach the column to the pedestal, in combination with the locking piece, to prevent the column turning, substantially as described and shown."

---

55. For an *Improvement in Grain Harvesters;* William H. Start, Smyrna, Delaware, June 24.

Claim.—"Having thus described my improved grain and grass cutter, what I claim as my invention, is, 1st, The standard to which the steering wheel is attached, constructed as herein described, so as to perform its own office proper, and also to adjust the cutter at the required height above the surface of the ground.

"2nd, The discharging rake, which is moved as described, in combination with the endless apron, for collecting and discharging the cut grain, as set forth."

---

56. For an *Improvement in Mashing Tubs;* Joseph Wright, Waterloo, New York, June 24.

Claim.—"What I claim as my invention, is, 1st, The employment of buckets formed by the revolving arms working within the hopper, for delivering the grain through suitable openings into, and operating in combination with the mashing cylinder, having an outlet (or outlets) for supplying the cooler, substantially as shown and described.

2nd, The use of a mashing cylinder, having beaters within it, and operating in combination with a cooler, carrying any number of barrels or shafts, fitted with projecting pins, essentially as shown and described, for the purposes set forth."

---

57. For an *Improvement in making Hemp from Okra;* Jean Blanc, New Orleans, Louisiana, June 24.

"The discovery which I have made consists in a new method of preparing hemp from

the bark of the okra plant, by grinding or mashing the plant while in its green state, and rotting the bark in water, thereby dissolving the glutinous matter which it contains, and afterwards washing it in water before drying."

Claim.—"What I claim as my invention, is the preparing of hemp from the bark of the okra plant in its green state, and the herein described method of preparing it for use."

RE-ISSUES FOR JUNE, 1851.

1. For a *Method of Attaching Augers to their Handles;* Esther L. Larkin, Administratrix of John E. Larkin, dec'd., patented November 19, 1850; re-issued June 17, 1851.

Claim.—"What I claim as my invention, is the handle, made in two parts, one of which D, fits in a socket B, on the other A, and carries a bolt *f*, screwed at its end; the said bolt passing through a hole in the auger shank, and screwing into a female screw or nut *a*, in the part A, for the purpose of clasping, or firmly holding the auger shank between the ends of the parts A and D of the handle or stock, substantially in the manner herein described."

DESIGNS FOR JUNE, 1851.

1. For a *Design for Stove Plates;* Lyman S. Hapgood, Boston, Massachussetts, June 3.

Claim.—"What I claim as my production, is the design, consisting of the mouldings, panels, and gothic arches herein above described and represented in the drawing, for the top and front plates of a parlor stove."

---

2. For a *Design for Stoves;* William L. Sanderson, Troy, New York, Assignor to R. R. Finch, Peekskill, New York.

Claim.—"What I claim as new, is the border A, with its corner pieces, the figures B, C, and D; the borders E, E, E, E, and F, F, said borders and figures being of the form and situated precisely as represented and described."

---

3. For a *Design for Stoves;* Samuel W. Gibbs, Assignor to Jagger, Treadwell, and Perry, Albany, New York, June 10.

Claim.—"What I claim as my production, is the combination and arrangement of ornamental forms and figures represented in the annexed drawings, forming the ornamental designs for front and side plates of a cooking stove, with the doors thereto belonging."

---

4. For a *Design for Stoves;* W. G. Hallman, Philadelphia, Pennsylvania, June 10.

Claim.—"Having thus fully described my design, what I claim therein is the design or ornamental pattern herein fully set forth and delineated."

---

5. For a *Design for Stoves;* A. Cox, Elias Johnson, and D. B. Cox, Troy, New York, June 10.

Claim.—"Having thus fully described our ornamental designs, what we claim, is the ornamental design stove pattern above described, formed of flat ribbons, as fully illustrated."

---

6. For a *Design for Stoves;* A. Cox, Elias Johnson, and D. B. Cox, Troy, New York, June 10.

Claim.—"Having thus fully described our improved design, what we claim, is the within described and illustrated ornamental design stove pattern."

---

7. For a *Design for Stoves;* John F. Rathbone, Albany, New York, June 10.

Claim.—"What I claim as my production, is the combination and arrangement of ornamental figures and forms represented in the accompanying drawings, forming together an ornamental design for a six plate stove."

8. For a *Design for Stoves;* David Stuart, and Jacob Beesley, Assignors to W. P. Cresson, Philadelphia, Pennsylvania, June 10.

Claim.—"We have thus detailed the particular ornamental designs on the respective plates which we wish to patent, and do hereby claim the exclusive right to the said ornamental designs for stove plates, as we have laid them out and displayed them."

---

9. For a *Design for Stoves;* Joseph G. Lamb, Cincinnati, Ohio. June 17.

Claim.—"Having thus fully described and shown the aforesaid design, what I claim as my invention, is the combination and arrangement of the above described and represented shapes, mouldings, and ornaments, substantially as herein shown."

---

10. For a *Design for Stoves;* Joseph G. Lamb, Cincinnati, Ohio, June 17.

Claim.—"Having thus fully described the various parts of the above named ornamental design, what I claim as new, and my invention, is the combination and arrangement of the herein represented shapes, ornaments, mouldings, and figures when combined and arranged substantially as shown."

---

11. For a *Design for Stoves;* Samuel A. House, Mechanicville, New York, June 24.

Claim.—"What I claim as new, is the design and configuration of box-stoves, substantially the same as herein described and represented."

JULY.

1. For a *Vice Saw-Set;* William Hinds, Otsego, New York, July 1.

Claim.—"What I claim as my invention, is constructing a vice for the purpose of compressing saws, to be set or filed, in the following manner, namely: with only one supporting arm to each jaw, hinged at their lower extremities, and having an extra arm on one side of, and parallel or nearly so, to said supporting arms, to the upper extremity of which is attached an eccentric lever, or its mechanical equivalent, for compressing the two jaws together; constructed substantially as herein described."

---

2. For *Arrangement of Catches on the Upper Sash, operated by moving the Lower Sash;* Washburn Race, Seneca Falls, New York, July 1.

"The nature of my invention consists in constructing and arranging the catches which hold up the upper sash of a window, in such manner that they can be operated to release the upper sash, and allow it to open, or to secure this sash in any desired position, either opened or closed, by means of the lower sash of the window, and without applying the hands either to the upper sash, or to its catches."

Claim.—"What I claim as my invention, is the arrangement herein described, of the catches and window sashes for the purpose described."

---

3. For an *Improvement in Boxes and Axles for Saving Oil;* Benjamin Kraft, Reading, Pennsylvania, July 1.

Claim.—"I claim causing the bevelled edges of the oil box to enter the grooves of the axle, and rest against their *outer* shoulders, but not against their inner shoulders; thus, at the same time, preventing end play and the escape of the oil, the journal bearing being lower than the bevelled edges of the oil box, and sufficiently above the bottom of it to prevent the oil coming from the box to the journal."

---

4. For an *Improvement in Inkstands;* Henry Whitney, jr., Cambridge, Massachussetts, July 1.

Claim.—"I do not claim the invention of the elastic diaphragm for inkstands, but I claim my inkstand as a new article of manufacture, in which the following features are, for the first time, associated, viz: an elastic diaphragm covered and secured from injury, by a metallic cap, and regulated by a screw passing through the cap, and in combination with the diaphragm, the funnels top, and waste cup."

5. For an *Improvement in Iron Fences;* John B. Wickersham, of the City of New York, July 1.

Claim.—"Having thus fully described the nature of my invention, and the manner of constructing the same, what I claim therein as new, is the manner herein described of securing the rails of iron fences, by means of sectional or divided parts, having slots therein, which are so arranged, that when in place they break joint with each other, the slot in one section extending upward, and the slot in the other downward, so closing the slots as to prevent the rails, which have a loop or dead eye turned on each end for that purpose, from passing through, or coming out, as herein fully set forth."

---

6. For an *Improvement in Bedsteads;* Harvey W. Sabin, Canandaigua, New York, July 1.

"The nature of my invention consists in providing the means of holding a bedstead together, and at the same time furnishing an elastic bottom."

Claim.—"What I claim as my invention, is the knuckle joints for holding the rails of the bedstead together, in combination with the rods, substantially in the manner and for the purpose described, said rods being also employed to support the slats forming the bottom of the bedstead."

---

7. For an *Improvement in Spectacle Frames;* John P. Paine, Worcester, Massachussetts, July 1.

"The nature of my invention consists in so combining a steel spring with the joint and temple of the frame, as to secure ease to the wearer, and safety to the frame."

Claim.—"What I claim as my invention, is the combination of the spring and cylin der with the temple bow and the glass frame, the whole being substantially as specified."

---

8. For an *Improvement in Grain Harvesters;* Aaron Palmer and S. G. Williams, Brock port, New York, July 1.

Claim.—"What we claim as our invention, is the discharging the cut stalks and heads of grain from the platform, by means of the combination of the rake with the lever, and the co-operation therewith of the series of teeth on the face of the wheel and the inclined rail rising above the curved guard of the platform, substantially in the manner herein set forth."

---

9. For an *Improvement in Bread Cutters;* Almon E. and Davenport Lazell, of Chick-opee Falls, Massachussetts, July 1.

"Our improvement consists in fitting a set of knives, each made in the form of an eccentric circle, to an arbor, and having them work in guides, and with holders in such a manner, that by causing them to revolve by means of a crank, (or otherwise,) a whole loaf may be cut into suitable slices, at every revolution, without breaking or crushing the bread."

Claim.—"What we claim as our invention, is the use of a series of knives or cutters made in the form of eccentric circles, or scrolls, with the cutting edge on the periphery, so as to represent a spiral line, or curve, when combined with the bars or ribs of the bed piece, which serve to sustain the loaf, and also to guide the knives, and with the fingers or prongs, which hold the loaf against the knives whilst cutting, and also act as outside guides, when the whole is constructed, arranged, combined, and operating substantially as herein described."

---

10. For an *Improvement in Piano Fortes;* Michael Miller, Rochester, New York, July 1.

Claim.—"What I claim as my invention, is the spring acting on the valve at D, in combination with the weight of the key, resting on the valve at E, for the purposes substantially as herein described and represented."

11. For an *Improvement in Machines for Making Hat Bodies;* Daniel Barnum, County of Philadelphia, Pennsylvania, July 1.

"I will illustrate the nature of my invention by remarking, that long experience has proved the small wire picker which is universally used in the common fur blower, to be the best means, or instrument, for opening the fibres of fur, and that the arrangement of the common fur blower consists of a feeding apron, feeding rollers, and a picker with numerous small wire teeth placed within a chamber having an aperture under the picker, for the admission of a current of air, to aid in throwing the fibres into the chamber."

Claim.—"Having thus fully described my inventions, and pointed out some of the modes in which I contemplate using them, and having referred to what was previously known in this branch of the arts, in order that my invention may be the better understood, I do hereby declare, that I do not claim the combination of a picker and chamber, having an aperture for the admission of air, such a combination having long been used for cleaning the fibres of fur. Nor do I claim the combination of these with a perforated exhausted former, such a combination having been described and referred to, as applicable to forming hats and other irregular forms, in an application for a patent, by T. R. Williams in 1840,* though it was not then claimed as invention. Nor do I claim the use of water to harden or to wet the hat body; such use being as old as the felting process, and is indispensably necessary in all hardening and felt process. Nor do I claim the hardening of a hat body on a cone; such a process having been described and patented to Wells, James, and Peck, 1837, † they using a solid cone, upon which a web was wound, to form the body, and numerous jets of steam were used to harden the same, or to wet it, as it was wound on the cone, there being no exhaust; and processes for hardening bodies on a perforated cone have also been described in 1840, by Williams and by Wells in 1846,‡ they both using water pressure to hold the fibres, while the cone and fibres are immersed. Nor do I claim any of the parts as my invention, except as they are used in new combinations and producing new and important results.

"But what I do claim as my invention, is the exhausting and suspending fan, with its casing and aperture, constructed, arranged, and operated, substantially as and for the purposes herein before particularly described, in combination with the picker, chamber, perforated exhausted former, and exhaust fan, arranged substantially as described and shown, by which arrangements and combinations, the several parts or their equivalents, perform their several and combined functions in a better manner, and produce better results, than has been heretofore attained, without any chamber, trunk, or tunnel, or any other means, to control the fibres, after being suspended in the air by the fan or between the fan and perforated exhausted cone or former, substantially as described and shown.

"I also claim the combined action of the currents of air, and the currents of numerous jets of hot water, in the hardening or wetting process, the currents of air performing the triple duty of holding the fibres on the former, and of aiding the water to penetrate the hat body, and, at the same time, to carry the surplus water through the perforations into the exhaust, thus effectually preventing injury to the hat body, from the accumulation of the surplus water, to wash it, while the wetting or hardening process is greatly facilitated, and the perfection of the work is secured, the whole process being accomplished by the combination of the several parts named, or their equivalents, for producing the currents of air and water, with the perforated former over the exhaust, in the manner and for the purposes substantially as herein described and shown.

"The effect of these improvements, is the production of a machine, combining the best means for opening fibrous materials and suspending them in the air, surrounding a perforated and exhausted former, and also of a new combination of means for hardening the fibres and completing the process, without removing the hat, or applying any pressure preparatory to the suspension of the pressure of the air, by which means, a great improvement is effected, as well in the forming of the hat, and in the process of hardening, as in the facility of operation. The whole being by combination of machinery heretofore unknown."

---

12. For an *Improvement in Lathes;* Thomas R. Bailey, Lockport, New York, July 1.

Claim.—"What I claim as my invention is, controlling the poppet centre, so that it

* See Journ. Frank. Inst. Vol. III, 2d Series, page 132.
† See Journ. Frank. Inst. Vol. XXII, 2d Series, page 41.
‡ See Journ. Frank. Inst. Vol. III, 3d Series, page 323.

releases itself after the turning is finished, by connecting it with a sliding bar, having a weight or its equivalent attached, and carrying a ratchet, which is held by a ratchet attached to the stationary bed, the said catch having an arm attached, which is struck by part of the cutter head, after the cut is finished, and released from the ratchet, substantially as herein shown."

---

13. For an *Improvement in Running Gear of Railroad Carriages;* Daniel W. Eames, West Turin, New York, July 1.

"The nature of my invention consists in attaching to the trucks or vehicles, any number of duplicate inclined wheels, resting upon opposite sides of the same rail, whereby the moving vehicles are, in a manner, tied to the rail, so that curves may be more easily traveled; also, not necessarily causing any deviation from the course, by breakage, or removal of one line of rail."

Claim.—"What I claim as my invention, is the employment of wheels in any number of pairs, attached, on either side, to the track or frame of railway vehicles, and set at any inclination to the horizon, converging to a point in or below the rail, so that both wheels of any one pair will rest or travel on opposite sides of the upper surface of either one or the same rail, essentially as shown and described."

---

14. For an *Improvement in Wire Hooks and Eyes;* Charles Atwood, Derby, Connecticut, July 1.

Claim.—"What I claim as my invention, is, 1st, The addition of side springs to the common forms of hooks and eyes, substantially in the manner and for the purposes set forth.

2d, "I claim the small ridges or elevations on each side of the break of the hook, made by bending the wire of the side springs, or by other means equivalent thereto, for the purposes set forth.

3d, "I claim the jews-harp form, or partly circular eyelets, extended, to form loops, adapted to receive tape, in connexion with the small elevations to keep the tape in its proper place, substantially as set forth."

---

15. For *Improvements in Machinery for Cutting Files;* John Crum, Ramapo, New York, July 1.

Claim.—"What I claim as my invention, is connecting the file blank to be cut, with a bed which has a positive feed motion, substantially as described, in combination with an incidental rolling motion, depending upon the shape of the blank, and the angle which the cutter forms therewith, substantially as described.

"I also claim connecting the chisel with its stock, by a joint, as described, in combination with a rolling bed as described, by which they are rendered self-adapting, as described.

"I also claim holding the file down on the bed during the operation of cutting, and near to the cutter, by means of a roller or its equivalent, combined with the rolling bed, substantially as herein described; but this I only claim when the end of the file is so connected with its bed, that it shall be free to move up and down, that the pressure of the roller may keep that part of the file that is being cut, firmly down on to the bed, as herein specified.

"I am aware that before the date of my invention, the cutter of file cutting machines has been jointed to a helve or bar; but in such cases it has not been combined with a rolling bed, and therefore, I do not wish to be understood as claiming broadly, the making of the cutter with a joint; but to claim this only under the limitations pointed out above.

"I am also aware that the file blank has been made to slide during the feeding motion, over a rolling bed, to adapt the transverse plane of the file blank to the line of the cutting edge, for cutting the different ranges of teeth, and, therefore, I do not wish to be understood as claiming broadly, the employment of a rolling bed, but to claim such rolling bed when made to move with the file, during the feed motion, from end to end, under the limitations above specified."

---

16. For an *Improvement in Handles of Brushes and Brooms;* Luke F. Cavanaugh, Newfield, New York, July 1.

Claim.—"Having thus described my improvements, what I claim as new therein, is

the lever jaws, held together by the head piece of the screw in combination with the conical end of the handle, substantially in the manner and for the purpose set forth."

---

17. For an *Improved Arrangement of the Steam Engine;* Frederick P. Dimpfel, City of New York, July 1.

Claim.—"What I claim as my invention, is the method herein described, of connecting the steam piston of a steam engine, with the crank thereof, by means of a piston rod, fixed cross head, side bars, forked connecting rod, and belts, or the equivalents thereof, these several devices being arranged and operating substantially as herein set forth, in such manner that the cross piece of the connecting rod, which is placed transversely to the crank shaft, shall be on opposite sides of the axial line of said shaft, at opposite extremities of the stroke of the piston.

"I also claim the belts or gimbal-rings, or the equivalents thereof, arranged substantially as herein set forth, for the purpose of transmitting the movement of the cross head to the connecting rod of a steam engine."

---

18. For an *Improved Mode of Papering Pins;* Chauncy O. Crosby, New Haven, Connecticut, July 8.

Claim.—"What I claim, therefore, as my invention is, the producing of a new manufacture of "pin rolls," either oblong, oval, cylindrical, square, or other shape or form, (so that it combines, in effect, the common sheeted pin paper or fillet, stuck, or inserted pin paper, or pins wound in closely between the layers, laps, or folds of fillet paper, with the common pin cushion,) whether the centre of the cushion is elevated or plane; that is, whether coned up or level, or whether the pins are inserted through crimps or not, and embraced by the fillet paper. The fillet embracing the shank or barrels of the pins, while the heads of the pins are not so embraced, but open and conveniently accessible to be withdrawn for use, without unfolding, unwinding, or disturbing the pin roll, substantially as herein described by the specification and drawings."

---

19. For an *Improved Portable Hydraulic Press;* Richard Dudgeon, City of New York, July 8.

Claim.—"What I claim as my invention is, an hydraulic press, quite portable, in which the ram is hollow, and serves as the reservoir, to supply the cylinder with water, or other liquid, while the force-pump and its appendages are contained within the ram; so that by working this force-pump, the ram is forced up, until the liquid in such ram is exhausted, and by moving the handle of the pump down, it will come in contact with a rod attached to a valve in the pump piston, and the latter comes in contact with a valve in the end of the ram, opening them both, and allowing the water to return into the ram again, through passages."

---

20. For an *Improved Mechanical Hooker-Up;* David J. Happersett, Downingtown, Pennsylvania, July 8.

Claim.—"What I claim as my invention is, in combination with a plate, or the equivalent thereof, for receiving the mass issuing from a rolling mill, the friction drums, the periphery of one of which is shaped substantially as described, and operating substantially as herein set forth, in such manner, that by their action, the plate, or its equivalent, is quickly raised and held stationary at the proper height, to permit the mass upon it to be passed to the front side of the mill, and is rapidly lowered to the proper position, to receive the mass issuing from the rolls."

---

21. For an *Improvement in Silk Covered Buttons;* Hirsch Heinemann, City of New York, July 8.

Claim.—"I do not mean to limit myself to the shape of the mould, nor to the pattern or color formed on the silk covering; neither do I claim to be the first who has used the split shank, plate, and washer, as that has been used with a glass bead for ornamental purposes; but I do not know of any one who has used this plate, shank, and washer, as the means for fastening a silk covered button, and at the same time, secure and hide the

ends of the silk cover in the hole of the mould, thereby making a durable, finished, and handsome ornamental button.

"Therefore, what I claim is the application of the plate, shank, and washer, to a silk covered button, for the purposes specified and as described and shown."

---

22. For an *Improvement in Machines for Grooving Lumber;* Birdsill Holly and John W. Wheeler, Seneca Falls, New York, July 8.

Claim.—"Having thus fully described our improvements, what we claim to have invented is, the method herein described, of forming grooves by circular saws and a deflecting throat, in combination with suitable cutters, as set forth."

---

23. For an *Improvement in Harvesting Machines;* William Jones, Bradford, Vermont, July 8.

Claim.—"Having thus fully described the construction and operation of my grain harvester, what I claim therein is, the use of rotating cutters, in connexion with the rotating rake and teeth, operating substantially as described.

"I also claim the novel manner of gearing the horses, or animal power, under the machine, so as to conduct the grain over them, and discharge it in a straight line, in the wake of the machine, substantially as herein described and made known."

---

24. For an *Improvement in Cork Cutting Machines;* William King, City of New York, July 8.

"The nature of my invention consists in such construction of a machine for giving the cylindrical form to the bottle corks, as will enable the workmen readily to adjust it, while actually cutting, to cut a perfectly formed cork of the largest size the "square" will admit. In all machines for this purpose, hitherto in use, the corks are cut to an uniform size; but in practice this is not found to be desirable, as from the peculiar nature of the material, it is difficult to provide "squares" of uniform size, and hence, where the machine must be set to cut a perfectly formed cork from "squares" of the smallest size, a loss of stock results on all others."

Claim.—"I do not confine myself, strictly, to the precise form of construction herein described, but claim to vary the same as desirable, while I produce the like results by equivalent mechanical means. What I claim as of my own invention is, the lifting block, susceptible of such adjustment, with reference to the edge of the knife, while the machine is in motion, that from squares of varying sizes perfectly formed corks may be cut, of the largest size each square will afford, the whole being constructed and operating substantially in the manner herein set forth."

---

25. For an *Improvement in Seeding Machines;* Samuel Pennock and Morton Pennock, Kennet Square, Pennsylvania, July 8.

Claim.—"Having thus fully described the construction, use, and operation of our several improvements on the seeding machine, what we claim therein as new is, 1st, we claim the employment of the oblique, recessed washer, in combination with the cylindrical cap, provided with inclined wings or projections, which match with the oblique recesses of the washer, in such a manner that the pressure produced thereupon, shall securely hold the cylindrical cap in the required position, when adjusted to increase or diminish the size of the seed receptacles.

"2d, We claim scolloping the end of the cylindrical cap of the distributing cylinder, and using in connexion therewith clamp screws, for holding the cylindrical cap in the required position.

"3d, We claim the employment of the pin, or its equivalent, when used in connexion with a clamp screw, and interior cylindrical cap, when properly adjusted, to increase or diminish the size of the seed receptacles.

"4th, We likewise claim providing one of the journal pins of each depositing tube with a cog, which is made to fit an opening in the arm of the drag bar, when it shall be turned frontward, nearly horizontal, for the purpose of detaching the depositing tube from the drag bar with facility, as described and shown in Fig. 18.

"5th, We further claim the employment of the trifurcated holding lever, in combina-

tion with the drag bar, and suspended depositing tube, for the purpose of holding the depositing tube in its proper position, during the operation of forming the drill and depositing the seed, and by which said trifurcated holding lever may be disengaged from the pin when an obstruction is visible, and allow the depositing tube to turn rearward when it shall have been struck, and thus save the pin from being broken; and this trifurcated holding lever we claim, or its equivalent.

"6th, We likewise claim causing the depositing tube to assume its proper position, after it shall have cleared the obstruction, by the action of the long arm of the trifurcated holding lever upon the cam or projection of the depositing tube; and this we claim as in the arrangement herein described and represented.

"7th, Lastly, we claim so combining a separate double arm with the frontward end of each drag bar, that it may be detached therefrom, as well as from the eyes or loops of the front transverse beam of the frame, as described in the specification."

---

26. For an *Improvement in Revolving Breech Fire Arms;* Parry W. Porter, Memphis, Tennessee, July 8.

Claim.—"Having thus described my self-loading, repeating fire arm, what I claim as my invention is, 1st, in combination with a cocking lever, I claim the two triggers arranged and operating in such manner, that the tripping of the hammer can be effected either in the ordinary manner, by pulling a trigger, or by the return movement of the cocking lever.

"2d, I claim the combination of the sliding bolt with the cap primer, the two being so arranged, that as the hammer is tripped by pulling the trigger, a cap is applied to one of the nipples of the chambered breech, by which means the chambers are revolved by the back motion of the cock, and capped by its forward motion; the capping by this arrangement being effected in one half the time in which it can be done by others heretofore devised.

"3d, I claim the construction of the cap and bullet passages, the powder magazine, and the exterior case, in such manner that the bullet and cap passages, and the included powder chamber, can be withdrawn from the exterior case which encloses them, to give free access to every part of said passages, and to facilitate the removal of obstructions therefrom, as described.

"4th, In combination with a revolving disk breech, I claim a spring powder charger, constructed and operated by the movement of the breech, as herein set forth.

"5th, In combination with a revolving chambered breech, I claim the stationary cap stripper, constructed and operating as herein set forth.

"6th, In combination with a revolving breech fire arm, I claim the spring dust-plate, which permits the escape of smoke, but prevents the entrance of dirt.

"7th, I claim the forward inclination of the spout of the bullet passage, in connexion with a turning breech, the two being so arranged that when the latter is turning, the bullet dropped into the chamber is pressed against the inclined portion of the spout, and is by it forced down in the chamber of the breech, the inclined surface of the spout thus performing the office of a rammer."

---

27. For an *Improved Apparatus for Punching Designs in Sheet Metal;* William T. Rudd, Amsterdam, Virginia, July 8.

Claim.—"What I claim as my invention, is the leather bed or die, in combination with a set of punches for puncturing purposes, when such set of punches and the die are used in connexion with proper rollers, substantially in the manner and for the purposes herein set forth."

---

28. For an *Improvement in Rakes to Harvesting Machines;* William H. Seymour, Brockport, New York, July 8.

"My improvements consist in a new arrangement for raking the grain from the machine; also, in the peculiar manner of constructing, arranging, and supporting the bearings of the gear shafts, by which the gearing is made more compact and convenient than it otherwise could be, which parts will be particularly described."

Claim.—"What I claim as my invention, is the rake attached for raking the grain from the machine, without hand labor, constructed and operated substantially as described."

29. For an *Improvement in Machines for Pressing Hats;* John Stearns, Templeton, Massachusetts, July 8.

Claim.—"What I claim as my invention, is the method of alternately lowering the pressing irons upon the hat block, and raising them therefrom, by mechanism, operating substantially as herein described, which is readily controlled by the attendant."

30. For an *Improvement in Lifting Jacks;* James St. John, City of New York, July 8.

Claim.—"What I claim as my invention, is the catch or button operated by the index bar, for the purpose of directing the action of the lever, substantially in the manner herein set forth."

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Demonstration of Foucault's Experiment. By CHARLES J. ALLEN.

In the demonstration of Foucault's experiment, published in the last number of the Journal, in stating the conclusion that the ball of the pendulum has (irrespective of the vibration) the same absolute motion as the several parts of the circle F H G, I omitted to show that the motion of any and every point in this circle is the same *in direction* as that of the centre B. The object of the present communication is to supply this omission. The defect was not observed in time to remedy it satisfactorily in my former article.

Fig. 1.

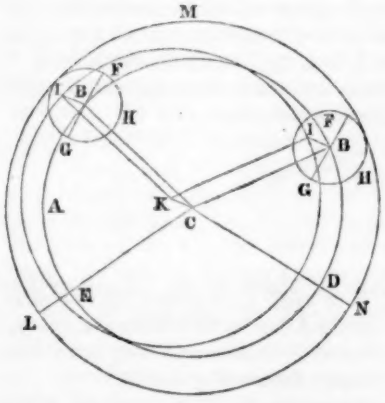
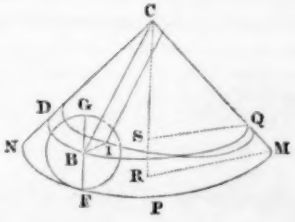


Fig. 2.



It is evident that the direction of motion of the points B and I at any particular time, (fig. 1, and also fig. 2 if F H G be supposed very small compared with the cone,) is represented by the tangents of their respective orbitual circles, drawn through these points; and since these tangents are perpendicular to the parallel radii B C, I K, they are themselves parallel; that is, the motion of the centre B of the circle F H G and that of any

point whatever in this circle are constantly parallel to each other; in other words, the several parts of the circle F H G are moving absolutely in the same direction. The same thing may be proved by joining B B, any two positions of the point B, and also I I, the corresponding positions of the point I; then these lines, since they join equal and parallel lines towards the same parts, are themselves equal and parallel; that is to say, the chords of the equal arcs described by the points B and I in the same time, are not only equal, but also parallel, and this is the case, however great or however small these arcs may be; but when these arcs are infinitely small, these chords coincide with their respective arcs—from which it follows, that the circumference of the circle of orbitual motion passing through I, has, *at the point I*, precisely the same direction that the circumference of the circle A B D E passing through the centre B has *at the point B;* which is, in effect, the same conclusion as that arrived at by the first method. There may, at first sight, be an apparent absurdity in this, inasmuch as the two circles of orbitual motion *cut* each other; but a little reflection will show that this absurdity is only apparent.

At the time my first article was sent to the editor of the Journal, I had seen no attempt at a regular and rigid demonstration of the new and interesting experiment. Subsequently, however, I have met with several articles in which the idea of the "*cone of latitude,*" as J. R. Young appropriately terms it, is more or less fully developed. Though indebted to no one for the employment of this means of simplifying the problem, it appears that the idea of the tangential cone had suggested itself to one or more other individuals before it had occurred to me.

Before leaving the subject, it may be well to observe that the denominator of the fraction in the formulas given on page 42 of last number, varies slightly with the latitude of the place—that there given (77787) being calculated for the latitude of 45°. A better form of the general expression for the value of y is the following, which is true for any latitude, s being the length (in feet or in the same denomination as l) of a pendulum beating seconds at the given place, viz:

$$y = \frac{r \sin. \text{L} \cos. a}{43082} \times \sqrt{\frac{l}{s}}$$

Philadelphia, 7th mo., 9th, 1851.

On the Velocity of Light.—Experimental Proof of the Theory of Undulation. By JOHN TYNDALL, *Ph. D., Marburg.**

1. *Méthode générale pour mesurer la vitesse de la lumière dans l'air et les milieux transparents,* by M. L. Foucault. *Comptes Rendus,* May 6, 1850.

2. *Sur la Vitesse comparative de la lumière dans l'air et dans l'eau,* by MM. H. Fizeau and L. Breguet. *Ibid.* June 17, 1850.

The state of Arago's sight has recently induced him to resign the carrying out of his proposition of submitting the two rival theories of light to experimental decision to physicists gifted with younger eyes. It is well known, that, according to the theory of Newton—the so called *emission theory*—the velocity of light in passing from a rarer medium into

* From the London, Edinburgh, and Dublin Philosophical Magazine, for June, 1851.

a denser is *increased.* For example, the index of refraction in passing from air to water is $\frac{4}{3}$; according to the emission theory, the velocity of light in air is to its velocity in water as 3 is to 4. Opposed to this stands the theory of undulation, proposed by Huyghens, and supported by Euler, Young, and Fresnel. According to this theory, the velocity of light in passing from a rarer to a denser medium is *diminished;* in the case of air and water, for instance, the above ratio is reversed; the velocity of light in air is to its velocity in water, in the ratio of 4 : 3. The genius of Fresnel has won for the latter theory almost universal recognition; a direct proof was however wanting, and this urged Arago* to the hardy thought of submitting the question to an experimental test.

The rotating mirror of Mr. Wheatstone was proposed as the instrumental agent for carrying out this idea. If we conceive a ray of light to enter a dark room through a hole in a window-shutter, and to fall upon the plane surface of a reflecting mirror set perpendicular to the direction of the light, the latter will be sent back along the path by which it entered. If the reflecting surface be oblique to the direction of the light, the latter will be reflected in some other direction; supposing a second reflecting mirror to be set perpendicular to this latter direction, the light will be reflected from this in the direction of the perpendicular, will again strike the other mirror, and be finally sent back by the latter through the aperture by which it entered. In this case the ray suffers two reflexions from the intermediate mirror; and if it be true that light requires time in passing from one point to another, these two reflexions *cannot occur contemporaneously.* A certain portion of time, however small, will be required for the journey to and fro from one mirror to the other. Supposing, for instance, the mirrors to be placed six feet apart; the light proceeding from the aperture is received upon the first mirror and reflected by it on to the other; from this it is reflected back again, and thus accomplishes a journey of twelve feet between its two reflexions by the first mirror. To this journey, as has been said, time is necessary. If the aperture and the two mirrors be perfectly motionless, the path of the light in coming, will coincide with its path in returning; but if, while on its route *between the two mirrors*, we conceive the position of the first mirror to be changed, that, for instance, it has become more inclined to the direction of the ray, the latter will not be reflected in the line of its approach, but will be thrown against the window shutter more or less to the side of the aperture. This change in the position of the mirror during the almost infinitesimal portion of time occupied by the light on its twelve feet journey, is accomplished by imparting to the mirror a high angular velocity, say a thousand revolutions in a second. We here find ourselves in possession of a means of comparing the velocity of light in air with its velocity in water. When the mirror rotates, the ray sent back does not strike upon the aperture, but more or less

* It ought to be mentioned, that the same subject had occupied the attention of Sir John Herschel and Mr. Wheatstone some years before it was mooted by Arago; and a proposition was actually made by the former to send a bar of light through a tube of water or alcohol a mile in length, and thus determine the influence of this medium. This idea, though not so practical, is the same in principle as that of Arago. The latter, however, was not aware that any such proposition had ever been made.

to the side of it. The less time occupied by the light in performing its double journey between the two mirrors, the less ought this divergence to be, and *vice versa*. Hence, if the Newtonian theory be true, the introduction of a column of water six feet long ought to bring the reflected image of the aperture *nearer* to the aperture itself; and if the undulation theory be true, the introduction of such a column ought to make the divergence *greater*. These speculations have been recently submitted to the test of experiment, and the result has pronounced in favor of the theory of undulation.

Of course, such experiments, though easily described and simple enough in principle, demand considerable delicacy of manipulation. The divergence spoken of is in reality exceedingly small. In order to observe it, M. Foucault has made use of a square aperture furnished with a number of vertical bars of fine platinum wire; eleven of these fitted in the space of one millimetre, and between each two there was a small space through which the light entered. The image given by this was a small field furrowed with alternate black and white stripes. The light after entering through this aperture fell upon a lens, by which it was converged, but before it came to a focus on the opposite side it fell upon the rotating mirror; it was thence cast upon a concave mirror placed about six feet distant, which reflected it back again. By a peculiar artifice, M. Foucault was enabled to compare with great nicety the divergence of the black and white stripes in the image from the platinum wires and their intervening spaces. "I have already proved," says M. Foucault, "by two successive operations, *that the deviation of the image after the journey of the light through air is less than after its journey through water.* I have also made another confirmatory experiment, which consists in observing an image formed partly by light which has passed through air, and partly by light which has passed through water. For small velocities, the stripes of this mixed image were apparently continuations of each other. *But by the acceleration of the motion the image is transported, and the stripes are broken at the point of junction of the air image with the water image. The stripes of the latter take the advance in the sense of the general deviation. Further, on taking into account the length of water and of air traversed, the deviations are found to be proportional to the indices of refraction.* These results indicate a velocity of the light *which is less in water than in air*, and, according to the views of M. Arago, fully establish the theory of undulation."

The following interesting article on the same subject is from MM. Fizeau and Breguet.

We have realized with great exactitude, the experiment described in our note presented to the Academy during its session of the 6th of May last; an experiment which we felt called upon to make, although M. Foucault in the same session had read an extended paper upon this subject, in which he announces that he has already obtained decisive results.

We have thought that, for the solution of a capital question like the present, the proofs could not be too much multiplied, and that experiments made under different circumstances could not but contribute to render our knowledge of an important fact more certain.

We have applied ourselves to the solution of the question as proposed by M. Arago in 1848; that is to say, How can the two opposite theories regarding the nature of light be submitted to a definite test? We have adopted such measures as are calculated to exhibit in a striking manner the differences of the phenomena as deduced from the one or the other theory.

As remarked in our preceding communication, the observation was made simultaneously on two bundles of light; the one having traversed the air, the other a column of water.

For each of these bundles the path was as follows:—A telescope was so disposed that its object glass was very near the rotating mirror; a little rectangular prism was placed in the focus of the telescope, in such a position that the solar rays falling upon it from a convenient lateral opening near the eye-glass, were totally reflected towards the object-glass.

Beyond the rotating mirror, and at a distance which for the ray that passed through water amounted to two metres, there was a fixed reflector designed to send back the light to the rotating mirror by a normal reflexion.

The focal distance of the telescope was such that the image of the little prism placed at its focus formed itself distinctly upon the fixed reflector just mentioned. After having been reflected from it, the light returned to the rotating mirror, was sent on through the telescope, and on passing the focus formed an image which exactly covered the prism.

By the rotation of the mirror we give birth to a number of images which succeed each other very rapidly, and the super-position of which produces the sensation of a permanent image.

When the rotation became sufficiently rapid, the permanent image was pushed forward in the direction of rotation, this deviation being the result of the angular motion of the mirror during the time occupied by the light in passing twice over the space which separated it from the fixed mirror.

A second similar fixed mirror was placed beside the former: it permitted us to make the experiment with air and water simultaneously.

If the lengths traversed had been equal for both media, the times occupied in passing them would be in the ratio of 4 : 3 or of 3 : 4, according to the one or the other theory, and the deviations produced by the rotation of the mirror would have been in the same ratio.

Instead of equal lengths, we have adopted equivalent lengths; that is to say, lengths traversed by the light in equal times. These lengths are very different, according as they are calculated from the one or the other theory. The length for water being 1, the equivalent length for air would be $\frac{3}{4}$ by the theory of emission, and $\frac{4}{3}$ by the theory of undulation.

If the experiment be made by adopting the length $\frac{3}{4}$ for air, that of water being 1, according to the theory of emission, the times occupied by the two bundles of light in passing over these spaces will be equal,

and consequently the deviations will be equal. By the other theory, on the contrary, the times occupied by the light in passing through both media, will be very different; these times will be for water and for air in the ratio of 16 to 9, and the deviations will be in the same ratio.

To coincide with the one or the other theory, it will therefore be sufficient to prove, either that the deviations are equal, or that one is nearly double the other.

If the equivalent lengths calculated from the theory of undulation be taken, the results will be similar, but inverse.

According to the theory of emission, the deviations will be in the ratio of 16 : 9; according to the other theory, they will be equal.

We have made these two experiments, and the results obtained are very exact. The phenomena observed are altogether in accordance with the theory of undulation, and in manifest opposition to the theory of emission.

In the first arrangement the deviation is greater for water than for air; it is nearly double. The difference is sensible with a velocity of 400 or 500 revolutions per second, with a velocity of 1500 revolutions it becomes quite evident.

In the second arrangement the deviation is the same for air and water; and whatever be the velocity of the mirror, there is no sensible difference between the two deviations.

These experiments have been made in the meridian room of the observatory; the column of water was 2 metres long, and was contained in a crystal tube closed at the ends with glass. This length is more convenient than that which we at first employed, namely, 3 metres. The light is less weakened, and, after its double passage, retains an intensity which may be estimated at double of that which was obtained with the tube of three metres.

The deviations were observed at a distance of 1·50 millim. from the rotating mirror.

On the Law of the Compressibility of Water at different Temperatures.

By W. J. Macquorn Rankine, *F. R. S. E. &c.**

Having lately had occasion, in the course of some theoretical researches on the velocity of sound in liquids, to endeavor to represent the experiments of M. Grassi on the compressibilities of distilled water at different temperatures (*Comptes Rendus*, xix.) by an empirical formula, I was much struck on unexpectedly finding that they followed sensibly this law:—

The compressibility of water is inversely proportional to the density multiplied by the temperature, as measured from the absolute zero of a perfect gas-thermometer, viz: a point 274°·6 below the ordinary zero of the Centigrade scale, and 462°·28 below that of Fahrenheit's scale.

* From the London, Edinburgh, and Dublin Philosophical Magazine, June, 1851.

Hence the compressibility of water varies according to the same law with that of a gas.

To express the law symbolically, let $\mathfrak{d}$ represent the fraction by which unity of volume of water is compressed by a pressure of one atmosphere, D the density of the water, its maximum density being taken as unity, and τ the temperature measured from the absolute zero; then

$$\mathfrak{d} = \frac{1}{K\tau D}.$$

K is a constant coefficient, the value of which is—

For the Centigrade scale, 72 atmospheres per degree.

For Fahrenheit's scale, 40 atmospheres per degree.

The following table exhibits a comparison between the results of the formula and those of M. Grassi's experiments. It will be observed, that the discrepancies are extremely small, and follow no regular law, being sometimes positive and sometimes negative.

The value of the single constant in the formula K was deduced from the mean of the first and second experimental results. The values of the density D were computed by means of the empirical formula in my paper On the Expansion of Liquids, published in the Edinburgh New Philosophical Journal for October, 1849.

Temperature Centigrade from the ordinary zero.	Compressibility of water per atmosphere of pressure.		Differences.
	Calculated.	Observed.	
0°	0·000050584	0·000050560	—0·000000024
10·8	0·000048679	0·000048705	+0·000000026
13·4	0·000048252	0·000048378	+0·000000126
15·5	0·000047915	0·000047745	—0·000000170
25·9	0·000046353	0·000045843	—0·000000510
34·8	0·000045140	0·000045573	+0·000000433
43·0	0·000044158	0·000044414	+0·000000256
53·3	0·000042931	0·000044336	+0·000001405

As it has not yet been ascertained whether this law is applicable to other liquids and to water at higher temperatures, I refrain for the present from drawing any theoretical conclusions from it.

London, March 1851.

For the Journal of the Franklin Institute.

Notes on the U. S. Tug Steamer "Engineer." *By* B. F. Isherwood, *Chief Engineer U. S. N.*

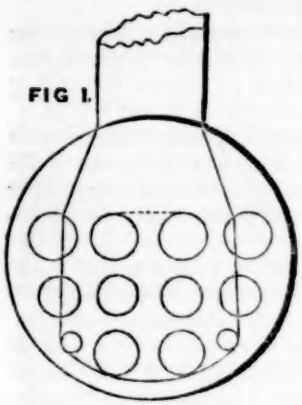
The "Engineer" is a small tug steamer attached to the Gosport Navy Yard, Va. The following particulars may be of advantage in the way of steam statistics:

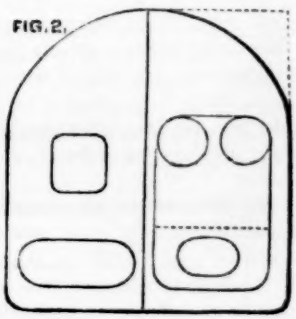
Hull.—Length between perpendiculars, 105 feet; beam, 17 feet 2 inches; depth of hold, 6 feet 11 inches; mean draft, 4 feet 6 inches; depth of keel, 6 inches; thickness of bottom plank, 2 inches; of wales, 3

inches; of siding frames, 4 inches at head and 8 inches at heel. Area of immersed amidship section, 61 square feet.

Engine.—One beam engine; diameter of cylinder 25 inches; stroke of piston, 7 feet; space displacement of piston per stroke, 23,863 cubic feet.

Paddle Wheel.—Of the common radial kind; diameter from outside to outside of paddles, 17 feet; length of paddle, 4 feet 3 inches; width of paddle, 1 foot 6 inches; thickness of paddle boards, $1\frac{3}{4}$ inches; number of paddles in each wheel, 14; wooden arms, $6\frac{1}{2}$ inches by 3 inches; immersion of lower edge of paddles, 29 inches; paddle-wheel shaft of cast iron, $6\frac{5}{8}$ inches diameter in main journal; area of one paddle, 6·375 square feet; number of paddles immersed in each wheel, 3.





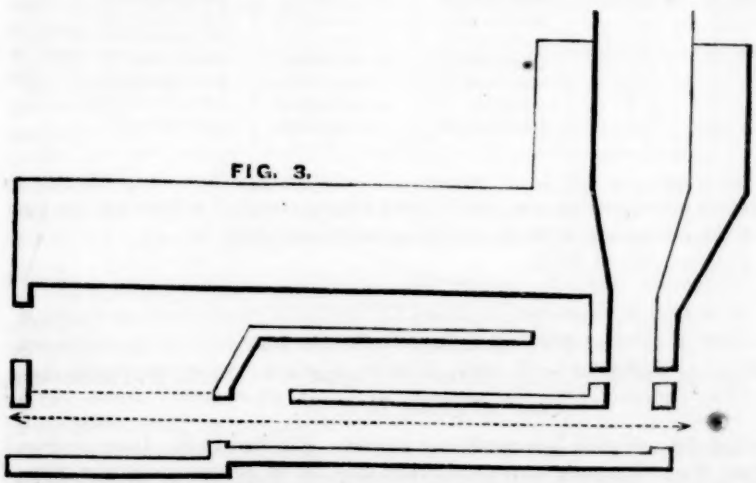


Fig. 1, cross section through flues. The straight lines show the connexion under smoke pipe.

Fig. 2, elevation—section through furnace.

Fig. 3, longitudinal section through flues.

Boiler.—One iron boiler of the "double return drop flue" variety, 17 feet long, 7½ feet diameter, with a steam chimney 5½ feet diameter, by 4 feet high above top of boiler; smoke pipe 2½ feet diameter, and 31 feet high above the top of steam chimney; two furnaces, 3 feet by 5 feet each; total fire grate surface, 30 square feet; heating surface in furnaces, 128 square feet; in flues 326 square feet; in connexions 62 square feet; total heating surface, 564 square feet; proportion of grate to heating surface, 1· to 18·8; proportion of grate surface to space displacement of piston, 1·257 square feet per cubic foot; proportion of heating surface to space displacement of piston, 23·631 square feet per cubic foot; capacity of steam room, 212 cubic feet, or 8·884 cubic feet per cubic foot of piston displacement.

Calorimeter, or cross areas of			flues at bridge	5·936	square feet, or 1· to	5·056	of grate.
"	"	"	middle flues,	4·746	" "	6·321	"
"	"	"	back connexions	3·529	" "	8·501	"
Area of smoke pipe,			- -	4·908	" "	6·113	"

With these proportions, the boiler furnishes steam for 20·9 double strokes of piston per minute of 21·8 pounds boiler pressure above the atmosphere, with wide throttle, burning 724 pounds of Virginia bituminous coal per hour with natural draught, cutting off at half stroke. Using dry Virginia pine wood, the boiler furnishes steam for 25 double strokes of piston per minute; of 30 pounds boiler pressure above the atmosphere, with wide throttle, burning half a cord per hour, cutting off at half stroke.

The cutting off was effected by an ordinary throttle valve placed in the steam pipe, and worked by a cam-board, operated by a cam on the main shaft. The cubic contents between the cut off valve and the commencement of the stroke of the piston, including clearance, was 2·02 cubic feet. Cutting off at half stroke, there was consequently used at each stroke of piston 13·95 cubic feet of steam. Taking the case in which coal was burned, when 724 pounds of coal per hour gave 20·9 double strokes of piston per minute of steam of 21·8 pounds boiler pressure above atmosphere, and supposing the initial pressure of steam in the cylinder to be two pounds less than in the boiler, or at a total pressure in the cylinder of 34·5 pounds, there would be evaporated per hour 13·95 cubic feet steam × 41·8 strokes of piston × 60 minutes, = 34986·6 cubic feet of steam. The relative volumes of steam and water at a steam pressure of 34½ pounds is 777½ to 1·, and $\frac{34986·6}{777·5} = 44·999$ cubic feet of water. Taking the cubic foot of sea water at 64·3 pounds, 44·999 × 64·3 = 2893·434 pounds of sea water evaporated per hour by 724 pounds of coal, or 3·996 pounds of sea water per hour per pound of coal; to this must be added the loss by "blowing off" at a saturation of $\frac{2}{32}$, which is $11\frac{8}{10}$ per cent. of the total caloric, or 13·38 per cent. of the caloric utilized, and 3·996 × 0·1338 = 0·535 and 3·996 + 0·535 = 4·531 pounds; a very low result, marking a badly proportioned boiler.

In the engine's log from which the above facts are obtained, there is recorded, "the smoke is very black, and fell to the surface of the sea at 16 or 18 yards from the smoke pipe," evidencing a very imperfect combustion; and in a letter from the engineer of the vessel, he remarks, "the draft is remarkably strong," a fact which might have been inferred from

the low proportion of heating to grate surface, viz: 18·8 to 1·, which being insufficient for the proper absorption of the caloric from the heated gases, they were delivered into the chimney at a very high temperature; and also from the large consumption of coal per square foot of grate surface, viz: 24·13 pounds. The quantity of clinker formed per hour, was 93 pounds, or 12·43 per cent., an excessive quantity, caused by the high temperature of the furnace resulting from the combustion of so large an amount of coal per square foot. The amount of ashes per hour, was 67·7 pounds, or 9·35 per cent. of the fuel. The amount of sea water evaporated per hour, per pound of coal per square foot of heating surface, was 6·864 pounds, inclusive of the loss by "blowing off," which is altogether too much for the economical use of fuel. In another part of the letter above referred to, from the engineer of the vessel, he says in reply to the question: Does the boiler foam? "Never under ordinary circumstances," which might have been deduced from the consideration that the steam room of the boiler contained 17·768 charges of steam for the cylinder, cutting off at half stroke. The data used in these notes are the mean of 40 hours continuous steaming in Chesapeake Bay, in July, 1849.

The quantity of atmospheric air chemically required for the complete combustion of one pound of bituminous coal, is 150·35 cubic feet. Of this amount, 44·64 cubic feet combines with the gases evolved by the heat from the coal, and the remaining 105·71 cubic feet combines with the solid carbon of the coal. Chemical experiment shows that when the gases (principally hydrogen and oxygen) are combined, the resulting mass is to the mass of atmospheric air required to furnish the oxygen as 10 to 11. The 44·64 cubic feet must therefore be increased in this proportion, and will become 49·104. The gases resulting from combination of the solid carbon and the oxygen, viz: carbonic acid and nitrogen gases, are of exactly the same bulk as the atmospheric air required to furnish the oxygen, viz: 105·71 cubic feet. The total masses then of atmospheric air and gases, will be 49·104 + 105·71 = 154·814. This, it must be remembered, would be the mass of the products of combustion in a *cool* state, and would be expanded by the heat of the furnace into a greater mass. The ordinary heat of a furnace has never been accurately ascertained, but is commonly estimated at about 1000° F., and as the permanently elastic gases follow the law of Mariotte, and expand about $\frac{1}{480}$th for each increment of one degree F., of temperature, it follows that the 154·814 cubic feet could be about trebled, or become 464·442 cubic feet. Taking the velocity of draft from Ure's experiments, at 36 feet per second, or 129600 feet per hour, (a high velocity,) there would be required to pass off 464·442 cubic feet, $\frac{464{\cdot}442}{129{\cdot}600} = 0\,00358$ square feet per pound of coal, and for 724 pounds, 2·592 square feet. This calorimeter or area of flue would therefore be required, provided a complete combination of the components of the coal and the oxygen of the atmosphere were obtained. Nothing like a complete combination, however, is obtained in practice; but from the experiments of Walter R. Johnson, De la Beche, and others, it appears that about 50 per cent. of the oxygen admitted into the furnaces of steam boilers, passes off uncombined.

The above obtained calorimeter should therefore be increased in the proportion of 150·35 to 309·628, or become 5·337; but it was actually at its minimum only 3·529 square feet, or *one-third less than it should have been.* The consequence was, as might have been predicted, a very imperfect combustion, and a shower of uncombined carbon falling at a few rods from the smoke pipe.

The inferior result obtained from this boiler, may be evidenced by the result obtained by Walter R. Johnson, from Virginia bituminous coal used in an experimental boiler. He obtained a mean evaporation of 7·27 pounds of fresh water per pound of coal.

We will now ascertain the result obtained in the boiler of the "Engineer," from the use of dry Virginia yellow pine wood. In the previous notes, it is stated that half a cord of this wood would maintain a steam boiler pressure of 30 pounds above atmosphere, giving 25 double strokes of piston per minute, cutting off at one half. As there would be 13·95 cubic feet of steam used per stroke, there would be used per hour $13·95 \times 50 \times 60 = 41850$ cubic feet; taking the initial pressure of the steam in the cylinder at two pounds less than in the boiler, we have a total steam pressure of $28 + 14·7 = 42·4$ pounds. The relative volumes of steam and water at this pressure are 643·4 to 1·, and $\frac{41850·}{643·4}$ = 65.045 cubic feet of water. Taking the cubic foot of sea water at 64·3 pounds, $65·045 \times 64·3 = 4182.393$ pounds of sea water evaporated by half a cord of wood. The mean weight of dry yellow pine wood per cord as piled, is about 2600 pounds, and $\frac{4182·393}{1300} = 3·217$. Adding to this the same per centage as before, for loss by "blowing off," viz: 13·38 per cent. of the caloric utilized, we have $3·217 \times 0·1338 = 0·430$; and $3·217 \times 0·430 = 3·647$ pounds of sea water evaporated per pound of wood. The evaporation per pound of coal being 4·531 pounds it follows that for equal weights, the coal is more efficient in the proportion of 1·242 to 1·000. From these figures, it also appears that the efficiency of one ton of Virginia bituminous coal of 2240 pounds, compared to that of one cord of Virginia dry yellow pine wood of 2600 pounds, is as 2782·08 to 2600·00, or as 1·07 to 1·00.

Performance.—The "Engineer" ran in Chesapeake Bay 360 miles in 39½ hours, or at the rate of 9·057 miles per hour. Double strokes of engine per minute, 20·9. Steam pressure in boiler above atmosphere, 21·8 pounds. Back pressure in condenser, 2·2 pounds; cut off at half stroke of piston. Supposing (which will be very near the truth as found in practice), that the initial steam pressure in the cylinder is two pounds less than in the boiler, we shall have a total initial steam pressure in cylinder of $(21·8 - 2 + 14·7 =)$ 34·5 pounds. Half the piston space displacement per stroke is 11·93 cubic feet, and the space comprised between the cut off in the steam pipe, and the piston at the commencement of the stroke, including clearance, is 2·02 cubic feet, making a total of 13.95 cubic feet of steam to be expanded into $(13·95 + 11·93)$ 25·88 cubic feet: $\frac{25·88}{13·95} = 1·855$, the hyper. log. of which is 0·6179,

and $0{\cdot}6179 \times 11{\cdot}93 = 7{\cdot}3715$, and $1{\cdot} \times 13{\cdot}95 = 13{\cdot}95$, and $\frac{7{\cdot}3715 \times 13{\cdot}95}{23{\cdot}863} = 0{\cdot}894$ = average effect of steam throughout stroke of piston, and $34{\cdot}5 \times 0{\cdot}894 = 30{\cdot}84$. Allowing the back pressure in the cylinder to exceed that in the condenser by 2 pounds, as found in practice, there would be a back pressure on the piston of 4·2 pounds to be deducted, leaving (30·84 — 4·20) 26·64 pounds as the mean effective pressure per square inch on the piston throughout the stroke.

The area of the piston being 490·875 square inches, and its stroke 7 feet, the horses power developed by the engine will be as follows:

$$\frac{490{\cdot}875 \times 26{\cdot}64 \times 41{\cdot}8 \times 7}{33000} = 115{\cdot}95 \text{ horses power.}$$

The circumference of the circle of the centre of resistance of the paddles is 50·391 feet, and

$50{\cdot}391 \times 20{\cdot}9 \times 60 = 63190{\cdot}31$ feet = speed of centre of reaction of paddles per hour.
$9{\cdot}057 \times 5280 = 47820{\cdot}96$ " = " " vessel per hour.

$15369{\cdot}35$ " = slip of centre of reaction of paddles per hour.

Or at 24.32 per cent.

The loss of labor from the oblique action of the paddles on the water, calculated as the squares of the sines of the angles of incidence, is 13·07 per cent.

Estimating the power required to work the engine at 2 pounds per square inch of piston, for an engine of this small size and great steam pressure, we have 7·51 per cent. of the total power thus consumed.

Taking from the experiments of Morin on friction 0·075 for the coefficient of friction for the load, and deducting first from the total mean effective pressure on the piston per square inch, viz: 26·64 pounds, the 2 pounds for working the engine, there remains 24·64 pounds, 0·075 of which is 1·848, and 1·848 is 6·94 per cent. of 26·64; 6·94 is therefore the per cent. of the total power developed by the engine, consumed in the friction of the load.

Collecting the above, we have the following:

Disposition of the power.

Slip of the centre of reaction of the paddles,	24·32	per cent., or	28·20	horses'	power.
Oblique action of the paddles, - -	13·07	" " "	15·15	"	"
To work the engine, - - - -	7·51	" " "	8·71	"	"
Friction of the load, - - - -	6·94	" " "	8·05	"	"
Leaving to be utilized in the propulsion of the vessel, - - - - -	48·16	" " "	55·84	"	"
Totals,	100·00		115·95		

The "Engineer" can tow a frigate at the rate of 2½ miles per hour. She is badly proportioned for a Tug, her wheels having too great a diameter for the power, consequently opposing too great a leverage for the engine to at all develope the power of the boiler, while at the same time, the paddles have altogether too little immersed surface to obtain the necessary resistance in towing; a great waste of effect in slip, is the inevitable result.

On Atmospheric Magnetism. *By* PROFESSOR FARADAY.

From the Proceedings of the Royal Institute of Great Britain, April 11, 1851.

On a former evening (January 24), it was shown that oxygen gas was magnetic, being attracted towards the poles of a magnet; and that like other magnetic bodies, it lost and gained in power as its temperature was raised and lowered, and that the change occurred within the range of natural temperatures. These properties it carries into the atmosphere; and the object, this evening, was to show how far they might be applied to explain certain of the observed variations of the terrestrial magnetic force.

If a source of magnetic power be considered (as a magnet) it presents us with a system having polarity; and if the parts which are called the poles be taken as representing the most concentrated condition of the polarity, then the contrary polarities, manifest externally in relation to the magnet, are perfectly definite, being exactly equal to each other. If the magnet be irregular in the disposition of its force, still the same definite character of the sum of the contrary polarities holds good.

External to the magnet those concentrations which are named poles may be considered as connected by what are called magnetic curves, or lines of magnetic force, existing in the space around. These phrases have a high meaning, and represent the ideality of magnetism. They imply not merely the directions of force, which are made manifest when a little magnet, or a crystal, or other subject of magnetic action, is placed amongst them, but those lines of power which connect and sustain the polarities, and exist as much when there is no magnetic needle or crystal there as when there is; having an independent existence analogous to (though very different in nature from) a ray of light or heat, which, though it be present in a given space, and even occupies time in its transmission, is absolutely insensible to us by any means whilst it remains a ray, and is only made known through its effects when it ceases to exist. The form of a line of magnetic force may vary exceedingly from a straight line to every degree of curvature, and may even have double and complicated curvatures impressed upon it. Its direction is determined by its polarity, the two changing together. Its powers are such, that a magnetic needle placed in it finds its place of rest parallel to it; a crystal of calcareous spar turns until its optic axis is transverse to it; and a wire which is unaffected when moved in or along it, has an electric current evolved the instant that it passes across it: by these and by other means the presence of the magnetic line of force and its direction are rendered manifest.

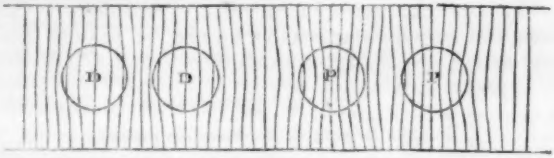
The earth is a great magnet: its power, according to Gauss, being equal to that which would be conferred if every cubic yard of it contained six one-pound magnets; the sum of the force therefore is equal to 8,464,000,000,000,000,000 such magnets. The disposition of this magnetic force is not regular, nor are there any points on the surface which can be properly called poles: still the regions of polarity are in high north and south latitudes; and these are connected by lines of magnetic force (being the lines of direction) which, generally speaking, rise out of the earth in one (magnetic) hemisphere, and passing in varied directions over the equatorial regions into the other hemisphere, there

enter into the earth to complete the known circuit of power. A free needle shows the presence and direction of these lines. In London they issue from the earth at an angle of about 69° with the horizon (being the dip or inclination); and the plane in which they rise forms an angle of 23° W. nearly with true north, giving what is called west declination. Where the dip is small, as at the magnetic equator, these lines scarcely rise out of the earth, and pass but a little way above the surface; but where it is large, as in northern or southern latitudes, they rise up at a greater angle, and pass into the distant realms of space, from whence they return again to the earth in the opposite magnetic hemisphere; thus investing the globe with a system of forces like that about an ordinary magnet, which wherever it passes through the atmosphere, is subject to the changing action of its magnetic oxygen. There is every reason to believe that these lines are *held* in the earth, out of which they arise and by which they are produced, just as the lines which originate in a magnet are held by it, though not in the same degree; and that any disturbance from above affecting them, will cause a greater change in their place and direction, in the atmosphere and space above, than in the earth beneath.

The system of lines of magnetic force around a magnet or the earth is related by a lateral tension of the whole, analogous in some degree to the lateral tension of lines of static electrical force; both the one and the other being easily made manifest by experiment. The disturbance of the tension in one part is accompanied instantly by a disturbance of the tension in every other part; for as the sum of the external powers of a system, unaltered at its origin, is definite and cannot be changed; so any alteration, either of intensity or direction amongst the lines of force at one place, must be accompanied by a corresponding change at every other. So if a mass of soft iron on the east side of a magnet causes a concentration of the lines of force from the magnet on that side, a corresponding expansion or opening out of the lines on the west side must be, and is at the same time produced; or if the sun, on rising in the east, renders all the oxygen of the air on that side of the globe less magnetic, and less able therefore to favor the transition of the lines of terrestrial force there, a greater number of them will be determined through the western region; and even though the lines of force may be doubted by some as having a separate existence, such as that above assumed, still no error as to the effects on magnetic needles would in that case be introduced, for they by experiment would be and are the same.

The power of a magnetic body as iron or oxygen to favor the transmission of lines of force through it more than other bodies not magnetic, may be expressed by the term conduction. Different bodies, as iron, nickel, oxygen, conduct in various degrees, and not only that, but the same body as iron or oxygen conducts in different degrees at different temperatures. When space traversed by uniform lines of magnetic force is occupied by a uniform body as air, the disposition of the lines is not altered; but if a better conducting substance than the air is introduced, so as to occupy part of the space, the lines are concentrated in it, and drawn from other parts as shown by P P in the figure, or if a worse conducting substance is introduced, the lines are opened out as at D D.

In both cases the lines of force are inflected, and a small magnetic needle standing in them at the inflected part, would have its direction changed accordingly. Experimental illustrations of these changes in direction are given in Mr. Faraday's paper in the Philosophical Transactions for 1851, Part I. Par. 2843, &c.



Now this by the hypothesis is assumed to take place in the atmosphere. Supposing it all at mean temperature, the lines of force would have the direction determined by the arrangement of the power within the earth. Then the sun's presence in the east would make all the atmosphere in that region a worse conductor, and cause it to assume the character of D; and as the sun came up to and passed over the meridian and away to the west, the atmosphere under his influence would bring up changes in direction like those shown in either D or D; it would therefore manifestly set a needle in a given latitude in opposite directions as it passed by; and as evidently set two needles in north and south latitudes in opposite directions at the same moment of time. As the night came on, and a temperature lower than the mean came up from the east and passed over, the lines of force would be inflected as in P or P, and a reverse variation of the needle to that which occurred before, would now take place.

That natural effects of variation must be produced consequent upon the magnetic nature of oxygen and its daily variations of temperature, is manifest; but whether they cause the observed variations, or are competent to do so, is a question that can only be decided after very careful inquiry. Observations are now made on the surface of the earth with extreme care in many places, and these are collated, and the average or mean result, as to direction and intensity of the earth's force, ascertained for every hour and season; and also many remarkable, anomalous, and extra results evolved. A theory of the causes of any or all of these variations may be examined first by the *direction* which the varying needle does or ought to assume, and then by the *amount* of the variation. The hypothesis now brought forward has been compared with the mean daily variation for all the months in the year at north and south stations, as Toronto and Hobarton, and at many others near to and far from the equator, and agrees in direction with the results observed far beyond what the author anticipated. Thus the paths described by the upper ends of free needles in the north and south hemispheres should be closed curves, with the motion in opposite and certain directions, and so they are:—the curves described by needles in north or south latitudes should be larger in summer and smaller in winter, and so they are:—a night or cold action should grow up in the winter months, and such is the case:—the northern hemisphere ought to have a certain predominance over the southern, because of its superior temperature, and that is so:—the disposition of land and water ought to have an influence, and there

is one in the right direction:—so that in the first statement and examination of the hypothesis, it appears to be remarkably supported by the facts. All these coincidences are particularly examined in o and stated in the Philosophical Transactions already referred to. The next step will be to ascertain what is the amount of change in the conducting power of the air for given changes of temperature, and then to apply that in the endeavor to ascertain whether the amount of change to be expected is (as well as the direction) accordant wi h that which really occurs.

For the Journal of the Franklin Institute.

A Series of Lectures on the Telegraph, delivered before the Franklin Institute. Session, 1850–51. *By* Dr. L. Turnbull.

Continued from page 61.

Gauss and Weber Electro-Magnetic Needle Telegraph.

Counsellor Gauss and Professor Weber, two of the most illustrious philosophers of Germany, to whom the science of magnetism is deeply indebted, entered nobly into the list in establishing, by means of electricity, telegraphic communication between the Astronomical Observatory, Physical Cabinet, and Magnetic Observatory, at Gottingen, the first notice of which is found in Göt. Gel. Anz., 1834, 1273, and in 1836, Schumacher Jahrback, p. 38–39. It consisted of a double line of wire carried over the houses and steeples at Gottingen. I was constructed chiefly for the purpose of being able to make investigations respecting the laws of the force of galvanic currents on a large scale, under different circumstances. The circuit employed in 1833 was about nine thousand feet; and in 1834 or 1835, at least fifteen thousand, but part of this wire was reeled. The form of wire employed was mostly copper, of the size known in commerce as No. 3, of which a length of one metre weighs eight grammes; the wire of the multiplier in the Magnetic Observatory was of silvered copper, No. 14, of 2·6 metres to the gramme. They first employed galvanic electricity by employing small sized plates, and found that the action was much increased by adding to their number. They repeated and perfected their first form of telegraph, by applying the phenomenon of magnetic induction, discovered by Prof. Faraday. The divers movements or the slow oscillations of magnetic bars, caused by the passage of the currents, and observed by the aid of a glass, furnished to Gauss and Weber all the signals which they wished in corresponding, but the number of signals which could be transmitted was few, and the time occupied by each considerable.

The main apparatus was a magneto-electric machine, and to this, Counsellor Gauss adapted a peculiar arrangement, by which the direction of the current can be reversed by a single pressure of the finger.

Professor Weber had a delicate apparatus for setting off an alarm of a clock, placed at the side of the magnet in the physical cabinet, by means of the current conducted from the observatory.

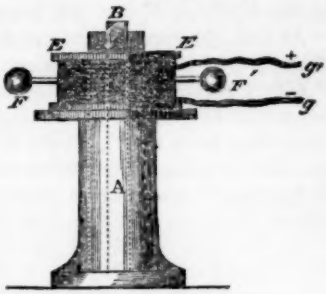
The telegraphing apparatus consisted of the following parts:

1. The apparatus for generating the galvanic current.
2. The apparatus for observing the given signal.

3. The apparatus for the sudden reversing of the current, or the commutator (*pole changer*).

In the column A, fig. 20, are two or three strong magnet bars (each of 25 pounds) united in one strong magnet—their poles of the *same name* (like poles) are visible at B. Over these bars the reel E is placed (of course having a hole for the bars to pass through), and around its external surface a copper wire (insulated by silk winding) is wound.

Fig. 20.

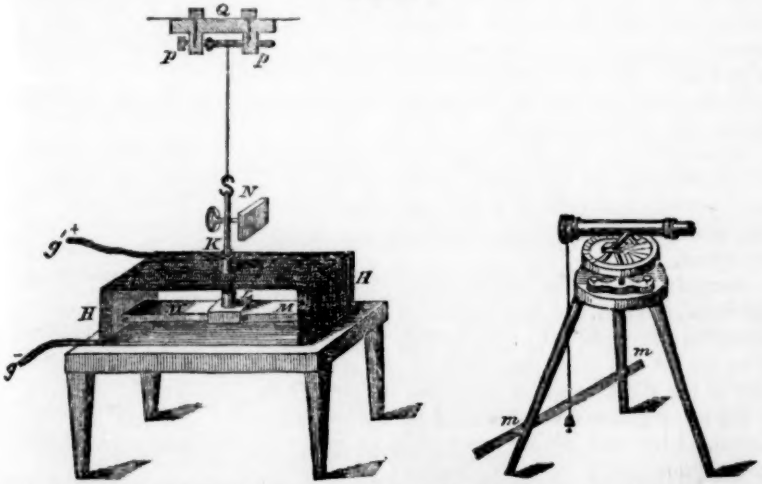


At the first arrangement, Gauss gave the reel 1050 coils; by a late arrangement, he increases the number of coils to 3537, with a length of wire of about 3600 feet; and still later, he used a reel with 7000 coils with a length of wire of more than 7000 feet.

The two ends, *g g′*, of this reel, E, (which on account of their inductive action are called *inductors*) are in connexion with a commutator (pole changer), and through that with the two principal conducting wires of the telegraph. If the inductor is taken by the two handles F F′, and suddenly drawn off the magnet bars on which it rests, and immediately, without turning it round, replaced in its former resting place, there results two induction currents, one immediately after the other, in opposite directions, passing through the conducting wire; the duration of these currents is very short. Their intensity depends upon the strength of the united magnets in A, upon the number of coils in the inductor E, and upon the distance these coils are from the magnets.

Fig. 21 represents the *observing apparatus*.

Fig. 21.



Whilst the inductor is set up at the station whence the signal is to be telegraphed, the observing apparatus is placed at the station where the communication is to be received.

It consists of a strong *multiplicator*, H H, that is to say, of a copper frame, around which an insulated wire is coiled. The two ends of the wire *g g* are connected with the two chief conducting wires coming from the other station, so that the multiplicator wire forms with the wire coiled on the inductor E, fig. 20, a single closed wire circuit.

At first, the multiplicator had 270 coils of wire, 2700 feet long; in later trials, it had 610 coils of wire, more than 6000 feet long.

In the coils of this multiplicator, there hangs for a magnetic needle a magnetic bar, M M, of at most 4 pounds in weight (later, 25 lb. magnetic bars were used), which is suspended by a thread easily movable in the *little ship* L. This thread consists of 200 parallel cocoon threads, and is fastened to a wooden screw, P Q P, at the ceiling of the room, by which it can be raised or lowered.

On the brass rod K, which passes through the copper frame H H, there is a vertical mirror, N, which turns with the magnet, and is directed in such a manner towards the *cypher scale*, *m m*, fastened at the foot of the stand of the spy-glass, R, that the image of the parts of the scale can be seen in the mirror through the spy-glass.

3. The apparatus contrived by Gauss for the rapid change of the direction of the current was somewhat complicated—but any other simple *commutator* can be used for the same purpose.

The following is the mode of using this telegraph: At the station from which a communication is to be sent, the inductor E, fig. 20, is suddenly drawn off, and again, without turning it round, thrust down upon the magnet pole B, by which means two induction currents of opposite directions are passed through the conducting wire.

By means of the first current, the magnet in the observing apparatus, fig. 21, at the other station, through the action of the multiplicator's coils, is made to diverge in a determined direction, for example, to the right. By means of the second current in the opposite direction, it is immediately stopped, so that the magnet can make no further *excursions*, but only, in consequence of the two opposite currents, makes a little lively vibration to one side, and then immediately remains quite still.

These small motions of the magnet are observed through the spy-glass R, fig. 21, in the mirror N.

In a state of rest, the image of the null point of the scale, *m m*, is visible through the spy-glass; by the motion of the magnet, the mirror is also moved, and reflects to the spy-glass another part of the scale. In this manner, the smallest motion of the magnet is perceptible by the spy-glass.

Accordingly as the commutator (which is directly attached to the inductor) is fixed, the *first* induction current passes in one or the opposite direction through the conducting wire—and therefore, by a sudden drawing off and thrusting down of the reel E, fig. 21, a magnetic vibration to the right or left at the other station can be produced at pleasure.

By an ingenious combination of several magnetic motions, to form a signal, Gauss and Weber were able to make all requisite signs (letters and cyphers) with these two *motions* (*first blows*).

The following are the alphabetical signs, as arranged:—

r	=	a	*rrr*	=	ck	*lrl*	=	m	*lrrr*	=	w	*llrr*	=	4
l	=	e	*rrl*	=	d	*rll*	=	n	*rrll*	=	z	*lllr*	=	5
rr	=	i	*rlr*	=	fv	*rrrr*	=	p	*rlrl*	=	0	*llrl*	=	6
rl	=	o	*lrr*	=	g	*rrrl*	=	r	*rllr*	=	1	*lrll*	=	7
lr	=	u	*lll*	=	h	*rrlr*	=	s	*lrrl*	=	2	*rlll*	=	8
ll	=	b	*llr*	=	l	*rlrr*	=	t	*lrlr*	=	3	*llll*	=	9

The variations of the magnetic needle signify a letter; *l* denotes a variation to the left, and *r* to the right, and by the combined deflexion of the needle, words and sentences may be transmitted.

Experiments of Messrs. Taquin and Ettieyhausen.

Messrs. Taquin and Ettieyhausen made experiments with a telegraphic line over two streets in Vienna, 1836. The wires passed through the air and under the ground of the Botanic Garden.—*Polytechnic Central Journal*, 1830, *Vail Electro-Magnetic Telegraph, p.* 189.

MORSE'S ELECTRO-MAGNETIC TELEGRAPH.

In the latter part of the year 1832, Samuel F. B. Morse, an ingenious American artist, while on a voyage homeward from Europe, conceived the idea of an electric or electro-chemical telegraph, and devised a system of signs for letters, to be marked by the breaking and closing of the electric or galvanic current.

Dr. C. T. Jackson, of Boston, a fellow passenger, well versed in the science of chemistry and electricity, and having witnessed numerous experiments during a recent visit to Paris, afforded him considerable assistance.

The following is a brief account of the methods proposed:—

1st. That electricity might be made visible in any part of the circuit, by dividing the wire, when a spark would be seen at the intersection.

2d. That it could be made to perforate paper if interposed between the disconnected wires.

3d. Saline compounds might be decomposed, so as to produce colors on paper.

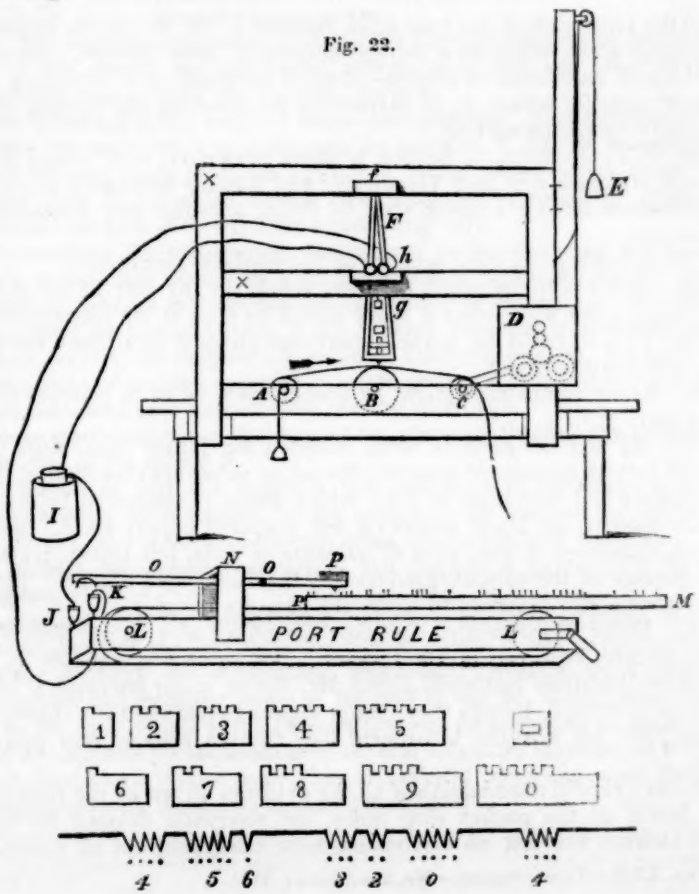
The 2d and 3d projects were adopted for future trial, since they would furnish permanent records; the saline substances mentioned, were the acetate and carbonate of lead, which when decomposed by the galvanic current, left black marks on the prepared paper; again, tumeric paper, moistened in a solution of sulphate of soda, left brown marks on the passage of the current, produced by the disengaged alkalie. Platina points were also proposed to effect the changes in color.

Mr. Morse experimented for some time after arriving in New York, independent, however, of Dr. Jackson. While on board the Sully, Dr. Jackson doubtless materially aided Mr. Morse in his conception of the electric telegraph, though they do not appear to have had any subsequent connexion, nor was the instrument they devised brought into practical use.

From a careful examination of all the evidence given by the passengers on board of the packet ship Sully, the telegraph devised by Morse and Jackson was not an electro-magnetic telegraph, but an electric or

electro-chemical telegraph (see letters of Dr. Jackson to Mr. Morse, and Morse's pamphlet, and letters of J. Francis Fisher, Esq., of Philadelphia). Mr. Morse cast some type in 1833, but from limited circumstances, was compelled to desist from farther experiment, until his appointment to a professorship in the University of New York, in 1835, when he formed the annexed mechanical arrangement, which is interesting from the fact, that it is the basis on which a long series of improvements have been made to bring the instrument to its present unique construction. He exhibited it in January, 1846, to Mr. L. D. Gale, a colleague professor in the University, of high scientific attainment, who afterwards joined Mr. Morse in his enterprise, and made some useful suggestions for its improvement. But becoming satisfied that the electro-magnetic power was more available for telegraphic purposes, as exemplified by the experiments of Prof. Henry and his own trials, he directed his attention to that agent. Mr. Gale gives the following description of the instrument, in his evidence in the case of F. O. J. Smith *versus* Hugh Downing:—

Fig. 22.



"A train of clock wheels were used to move a strip of paper, one half an inch in breadth. A, B, and C, are cylinders; the paper is unrolled from passing over the cylinder B to C, where it is connected to the clock work D, moved by the weight E. F is a wooden triangular shaped pendulum, suspended from the pivot *f*, over the centre of the cylinder B; its vibrations were across the paper, or at right angles to the motion of the latter. Through two cross-pieces in its lower part was fixed a pencil case, containing a pencil moving readily up and down, but kept in contact with the paper by a light weight, *g*.

An electro-magnet was fixed on the shelf *h*, which projected from the frame *XX*; this magnet attracted an armature affixed to the pendulum. One of the conductors of the magnet helix, passed to the single plate galvanic battery I, while the other joined the cup of mercury at the port rule K. The other pole of the battery was connected by a wire to the other cup of mercury J. The lower table represents a port rule; it consists of a rude frame containing two cylinders L L, two inches in diameter and two inches long, one turned by a crank, and that turning the other by a band one and half inch in width.

M, is a rule or composing stick, made of two small thin rules, two feet long, placed side by side, separated sufficiently far to form a trough for the type; the tops or cogs of the latter, are seen rising above the top of the rule M. A lever O O, is suspended from the united top of two standards that rise from the sides of the long frame of the post rule, on one end of which is a fork of copper wires that plunges when the lever is depressed into the two mercury cups K and J. A weight is attached to the other extremity to keep it down, and beneath this is a tooth, similar to the keys of a hand organ. There were eleven types one-eighth of an inch thick, having from one to five projections called cogs, save one that was used for a space. The first five numbers consisted from one to five cogs respectively, followed by a space, while the second five were the same, only having a long space double that of the first.

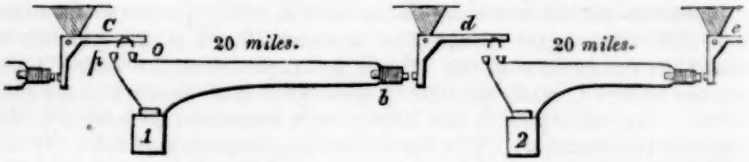
If, as an example, it was desired to send the number 456, the types 4, 5 and 6, with a space to separate them from the successive ones, were set up in the port rule M, which was placed on the bands of the port rule and sent forward by turning the crank; the cogs of the type operating the lever O O, broke and closed the circuit at the battery I; this being done, the magnet *h*, attracted the pendulum F, and moved the pencil *g*, about one-fourth of an inch; the pencil being in contact with the paper while it was moving, a continuous straight line was marked on it if the pendulum was stationary either at one or the other limit of its motion; but when attracted by the magnetic force, it marked a V shaped point as seen in the drawing; the points were marked on the moving paper as there shown by the successive breakings and closings of the circuits through the cogs of the type; the extremities of the V shaped marks were recognised for the figures by their number."

A dictionary was prepared, in which words were arranged in a manner that the numbers would represent them.

Mr. Morse found himself unable to make use of his instrument for great distances, from the resistance to, and dissipation of, the electrical current along the conductors. To overcome the difficulty, he adopted in the spring of 1837, a receiving magnet and a relay or repeating circuit. We

do not know by whom this was suggested, but its principle is based on the discoveries made by Prof. Henry, relative to the intensity magnet. Prof. Gale, Dr. Fisher, and Mr. Chilton, had referred Prof. M. to these investigations of Prof. Henry. Prof. Wheatstone, of London, exhibited to Profs. Henry, of Washington, and Bache, of the U. S. Coast Survey, in February, 1837, a repeating circuit which was closed by the deflexion of a galvanometer needle.

Fig. 23.



The one used by Mr. Morse is represented in the accompanying diagram. By means of the receiving magnet, the current of one battery was used to set off that of a second, the second a third, and so on, the last circuit being as strong as the first. 1 is a battery at one terminus of one line of conductors representing twenty miles in length; from one pole of which the conductor proceeds to the helix of an electro-magnet at the other terminus, (the helix forming part of the conductor;) from thence it returns to the battery and terminating in a mercury cup O. From the contiguous mercury cup, *p*, a wire proceeds to the other pole of the battery.

When the fork of the lever O, unites the two cups of mercury, the circuit is complete, and the magnet *f* is charged, and attracts the armature of the lever *d*, which connects the circuit of the battery 2 in the same manner, which again in turn operates the lever *e*, twenty miles further, and so on.

Publicity was given to it through the columns of the New York Observer, on the 15th of April, 1837, in consequence of an announcement that Messrs Gour and Servell had produced an instrument of miraculous capacity, to transmit information, which was, however, only an example of the visual telegraph; it was likewise noticed in the New York Journal of Commerce of April 27, 1837.

In September of the same year, an exhibition of the instrument working through 1700 feet of wire, was given at the New York University, to numerous visiters, among whom were some eminent scientific gentlemen. An account of this was given in the New York Journal of Commerce, of that date.

The ability of the instrument was so skilfully displayed, that Messrs. George and Alfred Vail were induced to "interest themselves in the invention, and furnish Prof. Morse with the means, material, and labor for an experiment on a larger scale;" at this time operations were commenced at the Speedwell Iron Works, near Morristown, New Jersey.

On the 10th of March, 1837, the Hon. Levi Woodbury, then Secretary of the Treasury, issued a circular, requesting information in regard to the propriety of establishing a system of Telegraphs for the United States. Prof. Morse sent three replies to this circular, containing an account of

his invention, its proposed advantages, and probable expense, with a description of the kind of conductors required; two of these letters dated respectively, September 27th, 1837, and November 28th, 1837, were included in a report of the Secretary to the House of Representatives, on the 6th of December, 1837. In this report, Mr. Woodbury gave a favorable view to the subject of telegraphing.

Some extracts from Prof. Morse's letters, will show how far real progress has exceeded his expectations at that time, and the modifications that have since been made.

September 27th, 1837.—"The principal expense will be the first cost of the wire, or metallic conductors, (consisting of four lengths,) and the securing them against injury. The cost of single copper wire $\frac{1}{16}$ of an inch in diameter, (and it should not be of less dimensions) for 400 miles was recently estimated in Scotland, to be £1000 sterling, including the solderings of the wires together, that is, $6 per mile for one wire."

"Iron tubes enclosing the wires, and filled in with pitch and resin, would probably be the most eligible mode of securing the conductors from injury, while at the same time it would be the most costly." "Iron tubes of $1\frac{1}{2}$ inch diameter, I learn, can be obtained at Baltimore, at 28 cents per foot. The trenching will not be more than three cents for two feet, or about $75 per mile." "If the circuit is laid through the air, the first cost will doubtless be much lessened." "Stout spars of some thirty feet in height, well planted in the ground, and placed about 350 feet apart, would in this case be required, along the tops of which the circuit might be stretched. Fifteen such spars would be wanted to a mile. This mode would be as cheap, probably, as any other, unless the laying of the circuit in the water should be found the most eligible." "I presume that five words can be transmitted in a minute; for, with the imperfect machine I now use, I have recorded at that rate, at the distance of half a mile."

November 28th, 1837.—"We have procured several miles of wire, and I am happy to announce to you that our success has, thus far, been complete. At the distance of five miles, with a common Cruikshank's battery of 87 plates, (4 by $3\frac{1}{2}$ inches each plate,) the marking was as perfect on the register as in the first instance of half a mile. We have recently added *five miles more*, making in all *ten miles*, with the same result, and we have no doubt of its effecting a *similar result* at *any distance*."

The instrument was partially described in Prof. Silliman's Journal of October, 1837, which was afterwards copied in the November number of the Journal of the Franklin Institute of the same year, and the London Mechanics' Magazine of February, 1838.

A model enclosing a circuit of ten miles of insulated wire wound upon two reels, was finished in the latter part of the year 1837, and intended for an exhibition before Congress. This was soon after shown in the Hall of the Franklin Institute of this city, where it was subjected to the inspection of a committee appointed to examine it; its operation was eminently satisfactory to them, and they did it the honor to give the subjoined favorable report:

"The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic

Arts, to whom was referred for an examination, an electro-magnetic telegraph, invented by Prof. F. B. Morse, of the city of New York, report—That this instrument was exhibited to them in the Hall of this Institute, and every opportunity given by Mr. Morse and his associate, Mr. Alfred Vail, to examine it carefully, and to judge of its operation. * * * *

"As exhibited to us, it was very satisfactory. The power given to the magnet at the register, through a length of wire of ten miles, was abundantly sufficient for the movements required to make the signals. The communication of this power was instantaneous. The time required to make the signals was as short at least as that necessary in the ordinary telegraphs. It appears to the committee, therefore, that the possibility of using telegraphs on this plan, in actual practice, is not to be doubted, though difficulties may be anticipated which could not be tested with the trial made with the model.

"One of these relates to the insulation and protection of the wires, which are to pass over many miles of distance, to form the circuits between the stations. Mr. Morse has proposed several plans; the last being to cover the wires with cotton thread, then varnish them thickly with gum elastic, and enclose the whole in leaden tubes. More practical and economical means will probably be devised; but the fact is not to be concealed, that any effectual plan must be very expensive. Doubts have been raised as to the distance to which the current of an ordinary battery can be made efficient; but the committee think no serious difficulty is to be anticipated on this point. * * * *

"An experiment is said to have been made on the Birmingham and Manchester railroad, through a circuit of thirty miles in length.

"It may be proper to state, that the idea of using electro-magnetism for telegraphic purposes has presented itself to several different individuals, and that it may be difficult to settle among them the question of originality.

"The celebrated Gauss has a telegraph of this kind in actual operation, for communicating signals between the University of Gottingen and his magnetic observatory in its vicinity. Mr. Wheatstone, of London, has been for some time also engaged in experiments on an electro-magnetic telegraph. But the plan of Prof. Morse is, so far as the committee are informed, entirely different from those devised by other individuals, all of which act by giving different *directions* to magnetic needles, and would therefore require several circuits of wires between all the stations.

"In conclusion, the committee beg to state their high appreciation of Prof. Morse's telegraph, and the hope that means may be given him to subject it to the test of an actual experiment made between stations at a considerable distance from each other. The advantages which this telegraph would present, if successful, over every kind heretofore used, make it worthy of the patronage of the government. These are, that the stations may be at a distance asunder far exceeding that to which other telegraphs are limited, and that the signals may be given at night, and in rains, snow, and fogs, when other telegraphs fail.

"By order of the Committee.

"William Hamilton, *Actuary.*

"*Philadelphia, February* 8, 1838."

It was subsequently taken to Washington, and kept in successful operation for several months in the room of the House Committee of Commerce, where it was visited by multitudes of people.

The examining committee were propitious to it, and in a warm and ardent report made on the 6th of April, 1838, urgently advised that it should be subjected to an adequate trial.

Prof. Morse sent in a caveat to secure his invention in October, 1837, filed his specifications, and made application for a patent in April, 1838, but withdrew them afterward, that he might be enabled to obtain patents in the European countries. Hon. F. O. J. Smith, a member of Congress, from Maine, was so interested in it, and sure of success, that he left his seat there, and joined Prof. Morse in a trip to Europe, in May, 1838. From the peculiar construction of the English patent laws (which require that the instrument should not have been published), he was unable to obtain a patent there, and though he secured one in France, it afforded him no profit, as his funds were too limited to bring it into operation within two years—the time specified in their patent regulations.

Though he failed at that time to remunerate himself as a monetary speculator, the instrument attracted the attention of scientific men in both countries, who accorded him much merit for the skilfulness of the invention.

It was put in operation at a meeting of the French Academy of Sciences, September 10th, 1838, and a description of it published in their weekly journal, the "Comptes Rendus." On account of the disordered financial condition of the country, and his own restricted means, no farther advancement was made after his return, until June, 1840, when he secured his first patent, which was given on the specifications of April, 1838, for the rude instrument already described, including a second electro-magnet used to give an alarm, without the improvement up to the former date.

Unable to proceed further on a more extensive scale of experiment, he procured the support of prominent scientific men in a petition to Congress during the December Session of 1842. Prof. J. Henry, in a deposition made in March, 1850, states of Mr. Morse as follows:

"Shortly after my return from Europe, in the autumn of 1837, I learned that Mr. Morse was about to petition Congress for assistance in constructing the electro-magnetic telegraph; some of my friends in Princeton, knowing what I had done in developing the principles of the telegraph, urged me to make the representation to Congress, which I had expressed some thoughts of doing, namely, that the principles of the electro-magnetic telegraph belong to the science of the world, and that any appropriation which might be made by Congress, should be as a premium for the best plan, and the means of testing the same, which the ingenuity of the country might offer. Shortly after this, I visited New York, and there accidentally made the personal acquaintance of Mr. Morse. He appeared to be an unassuming and prepossessing gentleman, with very little knowledge of the general principles of electricity, magnetism, or electro-magnetism. He made no claims, in conversation with me, to any scientific discoveries, or to anything beyond his particular machine and process of applying known principles to telegraphic purposes. He explained to me his plan of a telegraph, with which he had recently made a successful

experiment. I thought this plan better than any with which I had been made acquainted in Europe. I became interested in him, and instead of interfering with his application to Congress, I gave him a certificate in the form of a letter, stating my confidence in the practicability of the electro-magnetic telegraph, and my belief that the form proposed by himself was the best that had been published.

"Mr. Morse subsequently visited Princeton several times, to confer with me on the principles of electricity and magnetism, which might be applicable to the telegraph. I freely gave him any information which I possessed."

In respondence to his petition, Congress appropriated $30,000 for the purpose of testing its practical application. Thus enabled to prosecute his favorite theme with a freer element and more liberal spirit of investigation, he had the great gratification to exhibit to the American people his invention, working in an eminently successful manner, for a distance of forty miles, between the cities of Baltimore and Washington, in the month of June, 1844.

Prof. Morse has obtained for his instrument several distinct patents; the first was dated June 20, 1840; there were many important modifications introduced, such as a signal lever key substituted for the port rule, and a lever in the register in place of the pendulum, when it was exhibited before Congress, in 1838; this was re-issued January 15, 1846. A second patent was taken out on the 11th of April, 1846, containing the above alterations, with the addition of a local circuit and register, receiving magnet and adjuster, self-regulating break, the metal pen points, and grooved rollers for them to work in.

To be Continued.

On Steam Boilers and the Causes of their Explosion. *By* W. Fairbairn, Esq., C. E., F. R. S., &c.*

The following is an abstract of two lectures delivered by Mr. Fairbairn, on the 23d and 24th of April, at Leeds. The reputation of the author would be sufficient to secure for them the careful attention of practical men, even if recent sad occurrences had not roused the proprietors of steam boilers from the state of fatal indifference to the safety of their work people in which a large number of them seem buried. Great credit is due to Mr. Fairbairn for devoting his time and the results of his experience for the public advantage, and we are satisfied that this method of treating the subject will do more towards enlightening the public mind, and tend more to the prevention of boiler explosions, than any legal enactments that could be devised. The time of professional men is too valuable to them to admit of their giving their services gratuitously, but we think that government might well bestow such a sum annually as would provide for the public instruction upon such subjects as boiler and colliery explosions, sanatary measures, and the like.—*Ed. of the Artizan.*

*From the London Artizan, for June, 1851.

I propose to consider the boiler in its *construction, management, security,* and *economy.*

1st. As to the construction. Here I shall have to go a little into detail, in order to show, in construction, the absolute necessity there exists for adhering to form and other considerations, essential in the practice of mechanical engineers, in effecting the maximum of strength with the minimum of material. In boilers this is the more important, as any increase in the thickness of the plates obstructs the transmission of heat, and exposes the rivets as well as the plates to injury on the side exposed to the action of the furnace.

It has generally been supposed that the rolling of boiler plate iron gives to the sheets greater tenacity in the direction of their length than in that of their breadth: this is, however, not correct; as a series of experiments which I made some years since, fully proves that there is no difference in the tensile strength of boiler plates when torn asunder in the direction of the fibre, or across it. From five different sorts of iron the following results were obtained:—

Description of Iron.	Mean breaking weight in tons in the direction of the fibre.	Mean breaking weight in tons across the fibre.
Yorkshire Plates	25·77	27·49
Yorkshire Plates	22·76	26·37
Derbyshire Plates	21·68	18·65
Shropshire Plates	22·82	22·00
Staffordshire Plates	19·56	21·01
Mean	22·51	23·10

From this it appears that we may safely use iron plates in the construction of boilers in whatever direction may best suit the convenience of the maker. Next to the tenacity of the plates, comes the question of riveting, or the best and surest means of securing them together. On this part of the subject we have been widely astray, and it required some skill and no inconsiderable attention in conducting the experiments, to convince the unreflecting portion of the public—and even some of our boiler makers—that the riveted joints were not stronger than the plate itself. At first sight, this would appear to be the case, but a moment's reflection will soon convince us to the contrary, as in punching holes along the edge of a plate it is obvious that the plate must be weakened to the extent of the sectional areas punched out, and that it is next to impossible, under the circumstances, to retain the same strength in the material after such diminution has been effected as existed in the previously solid plate. This was clearly demonstrated by a series of experiments which took place some years since, and in which the strength of almost every description of riveted joint was determined by tearing them directly asunder. The results obtained from these experiments were conclusive, as regards the relative strength of riveted joints and the solid plates. In two different kinds of joints—double and single riveted—the strengths were found to be, in the ratio of the plate as the numbers 100, 70, and 56.

Assuming the strength of the plate to be	100
The strength of a double riveted joint would be, after allowing for the adhesion of the surfaces of the plate	70
And the strength of a single riveted joint	56

These proportions of the relative strengths of plates and joints may therefore in practice be safely taken as the standard value, in the construction of vessels required to be steam and water tight, and subjected to pressure varying from 10 lbs. to 100 lbs. on the square inch.

In the construction of boilers exposed to severe internal pressure, it is desirable to establish such forms, and so to dispose the material, as to apply the greatest strength in the direction of the greatest strain; and in order to accomplish this, it will be necessary to consider whether the same arrangement be required for all diameters, or whether the form as well as the disposition of the plates should not be changed. To determine these questions in cylindrical boilers, recourse must be had to experiment, or such deduction as may apply to any given case, and such as is founded upon unerring data derived from experimental research. On this head I am fortunate in having before me the calculations of Professor W. R. Johnson, of the Franklin Institute of America, whose inquiries into the strength of cylindrical boilers are of great value, and from which the following short abstract may be useful.

"1st. To know the force which tends to burst a cylindrical vessel in the longitudinal direction, or, in other words, to separate the *head* from the curved *sides;* we have only to consider the actual area of the head, and to multiply the units of *surface* by the number of units of *force* applied to each superficial unit. This will give the total *divellent* force in that direction.

"To counteract this, we have, or may be conceived to have, the tenacity of as many longitudinal bars as there are lineal units in the circumference of the cylinder. The united strength of these bars constitutes the total retaining or *quiescent* force, and at the moment when rupture is about to take place, the *divellent* and the quiescent forces must obviously be equal.

"2d. To ascertain the amount of force which tends to rupture the cylinder along the curved side, or rather along the opposite sides, we may regard the pressure as applied through the whole breadth of the cylinder upon each lineal unit of the diameter. Hence the total amount of force which would tend to divide the cylinder in halves, by separating it along two lines, on opposite sides, would be represented by multiplying the diameter by the force exerted on each unit of surface, and this product by the length of the cylinder. But even without regarding the length, we may consider the force requisite to rupture a *single band* in the direction now supposed, and of one lineal unit in breadth; since it obviously makes no difference whether the cylinder be long or short, in respect to the ease or difficulty of separating the sides. The *divellent* force in this direction is therefore truly represented by the diameter multiplied by the pressure per *unit of surface*. The retaining or *quiescent* force, in the same direction, is only the strength or tenacity of the two opposite sides of the supposed band. Here also at a moment when a rupture is about to occur, the divellent force must exactly equal the quiescent force."

Mr. Johnson then goes on to show that as the diameter is increased, the product of the diameter and the force or pressure per unit of surface is increased in the same ratio. This truism I shall endeavor to prove; as

also, that as the diameter of any cylindrical vessel is increased, the thickness of the metal must also be increased in the exact ratio of the increase of the diameter, the pressure, or, as Mr. Johnson calls it, the divellent force being the same; when the diameter of a boiler is increased, it must be borne in mind that the area of the ends is also increased, not in the ratio of the diameter, but in the ratio of the square of the diameter, and it will be seen that instead of the force being doubled, as is the case in the direction of the diameter and circumference, it is quadrupled upon the ends, or, what is the same thing, a cylinder double the diameter of another cylinder has to sustain four times the pressure in the longitudinal direction.

The retaining force or the thickness of the metal of a cylindrical boiler does not, however, increase in the same ratio as the area of the circle, but simply in the ratio of the diameter; consequently, the thickness of the metal will require to be increased in the same ratio as the diameter is increased. From this it appears that the tendency to rupture by blowing out the ends of a cylindrical boiler will not be greater in this direction than it is in any other direction; we may, therefore, safely conclude, since we have seen that the tendency to rupture increases in both directions in the ratio of the diameter, that any deviation from that law, as regards the thickness of the plates, would not increase the strength of the boiler.

I have been led to these inquiries from the circumstance that Mr. Johnson appears to reason on the supposition that there are no joints in the plates, and that the tenacity of the iron is equal to 60,000 lbs., rather more than 26 tons to the square inch. Now we have shown by the results of the experiments already adduced, that ordinary boiler plates will not bear more than 23 tons to the square inch, and as nearly one-third of the material is punched out for the reception of the rivets, we must still further reduce the strength, and take 15 tons, or about 34,000 lbs.* on the square inch, as the tenacity of the material, or the pressure at which a boiler would burst.

This I should consider in practice as the maximum power of resistance of boiler plates in their riveted state, and I will now trouble you to follow me in a very concise, and I trust not uninteresting investigation as to the bearing powers of boilers, and the pressure at which they can be worked with safety.

It has been stated that the strengths of cylindrical boilers, when taken in the direction of their circumference, are in the ratio of their diameters, and when taken in the direction of the ends, as the squares of the diameters, a proposition which it will not be difficult to demonstrate as applicable to every description of boiler of the cylindrical form. It will be seen, however, that the strain is not exactly the same in every direction, and that there is actually less upon the material in the longitudinal direction, than there is upon the circumference. For example, let us take two boilers, one three feet diameter and the other six feet, and suppose

* By experiment it is found that the strength of the riveted joints of boilers is only about one-half the strength of the plate itself; but taking into consideration the crossing of the joints, 34,000 lbs. may reasonably be taken as the tenacity of the riveted plates, or the bursting pressure of a cylindrical boiler.

each to be subject to a pressure of 40 lbs. to the square inch. In this condition, it is evident that the area or number of square inches in the end of a three-feet boiler is to that of the area of the six-feet boiler as 1 to 4, and by a common process of arithmetic it will be found that the edges of the plates forming the cylindrical part of the three-feet boiler is subject (at 40 lbs. on the square inch) to a pressure of 40,712 lbs.—upwards of 18 tons—whereas the plates of the six-feet boiler have to sustain a pressure of 162,848 lbs., or 72 tons, which is quadruple the force to which the boiler only one-half the diameter is exposed; and the circumferences being only as two to one, there is necessarily double the strain upon the cylindrical plates of the large boiler. Now this is not the case with the other parts of the boiler, as the circumference of a cylinder increases only in the ratio of the diameter; consequently the pressure, instead of being increased in the ratio of the squares of the diameter, as shown in the ends, is only doubled, the circumference of the six-feet boiler being twice that of the three-feet boiler.

Let us, for the sake of illustration, suppose the two cylindrical boilers, such as we have described, to be divided into a series of hoops of one inch in width; and, taking one of these hoops in the three-foot boiler, we shall find it exposed at a pressure of 40 lbs. on the square inch, to a force of 1440 lbs., acting on each side of a line drawn through the axis of a cylinder 36 inches diameter, and 1 inch in depth, and which line forms the diameter of the circle. Now this force causes a strain upon any two points in the three feet circle of 720 lbs., and assuming the pressure to be increased till the force becomes equal to the tenacity or retaining powers of the iron, it is evident, in this state of the equilibrium of the two forces, that the least preponderance on the side of the internal pressure would insure fracture. And, suppose we take the plates of which the boiler is composed at one quarter of an inch thick, and the ultimate strength at 34,000 lbs. on the square inch, we shall have $\frac{34,000}{36 \times 2} = 472$ lbs. per square inch as the bursting pressure of the boiler. Again, as the forces in this direction are not as the squares, but simply as the diameter, it is clear that at 40 lbs. on the square inch, we have in a hoop an inch in depth, or that portion of a cylinder whose diameter is 6 feet, exactly double the force applied, as was acting in the diameter of 3 feet. Now, assuming the plates to be a quarter of an inch thick, as in the three-feet boiler, it follows, if the forces at the same pressure be doubled in the large cylinder, that the thickness of the plates must also be doubled in order to sustain the same pressure with equal security; or what is the same thing, the six-feet boiler must be worked at half the pressure, in order to secure the same degree of safety as attained in the three-feet boiler at double the pressure. From these facts it may be useful to know, that boilers having increased dimensions should also have increased strength in the ratio of their diameter; or, in other words, the plates of a six-feet boiler should be double the thickness of the plates of a three-feet boiler, and so on in proportion as the diameter is increased.

The relative powers of force applied to cylinders of different diameters become more strikingly apparent when we reduce them to their equiva-

lents of strain per square inch, as applied to the ends and circumference of the boiler respectively. In the three-feet boiler, working at 40 lbs. pressure, we have a force equal to 720 lbs. upon an inch width of plate, and one quarter of an inch thick, or 720 by 4 equals 2880 lbs., the force per square inch upon every point of the circumference of the boiler.

Let us now compare this with the actual strength of the riveted plates themselves, which taken as before at 34,000 lbs. on the square inch, we arrive at the ratio of pressure as applied to the strength of the circumference as 2880 to 34,000, nearly as 1 to 12, or 472 per square inch, as the ultimate strength of the riveted plates.

These deductions appear to be true in every case as regards the resisting powers of cylindrical boilers, to a force radiating in every direction from its axis towards the circumference; but the same reasoning is, however, not maintained when applied to the ends, or, to speak technically, to the angle iron and riveting where the ends are attached to the circumference. Now, to prove this, let us take the three-feet boiler where we have 113 inches in the circumference, and upon this circular line of connexion we have, at 40 lbs. to the square inch, to sustain a pressure of 18 tons, which is equal to a strain of 360 lbs., acting longitudinally upon every inch of the circumference. Apply the same force to a six-feet boiler, with a circumference or line of connexion equal to 226 inches, and we shall find it exposed to exactly four times the force, or 72 tons; but in this case it must be borne in mind that the circumference is doubled, and consequently the strain, instead of being in the quadruple ratio, is only doubled, or a force equal to 720 lbs., acting longitudinally as before upon every inch of the circumference of the boiler. From these facts we come to the conclusion that the strength of cylindrical boilers is in the ratio of their diameters if taken in the line of curvature, and as the squares of the diameters as applied to the ends or their sectional area; and that all descriptions of cylindrical tubes, to bear the same pressure, must be increased in strength in the direction of their circumference simply as their diameters, and in the direction of the ends as the squares of the diameters.

Again, if we refer to the comparative merits of the plates composing cylindrical vessels, subjected to internal pressure, they will be found in this anomalous condition, that the strength in their longitudinal direction is twice that of the plates in the curvilinear direction. This appears by a comparison of the two forces, wherein we have shown that the ends of the three-feet boiler, at 40 lbs. internal pressure, sustain 360 lbs. of longitudinal strain upon each inch of a plate a quarter of an inch thick, whereas the same thickness of plates have to bear in the curvilinear direction a strain of 720 lbs. This difference of strain is a difficulty not easily overcome, and all that we can accomplish in this case will be to exercise a sound judgment in crossing the joints, the quality of the workmanship, and the distribution of the material. For the attainment of these objects, the following table, which exhibits the proportionate strength of cylindrical boilers from 3 to 8 feet in diameter, may be useful.

Table of equal strength in Cylindrical Boilers from 3 to 8 feet diameter, showing the thickness of metal in each respectively, at a pressure of 450 lbs. to the square inch.

Diameter of Boilers.		Bursting pressure — equivalent to the ultimate strength of the riveted joint — as deduced from experiment. 34,000 lbs. to the square inch.	Thickness of the plates in decimal parts of an inch.
Feet.	Inches.		
3	0	450 lbs.	·250
3	6		·291
4	0		·333
4	6		·376
5	0		·416
5	6		·458
6	0		·500
6	6		·541
7	0		·583
7	6		·625
8	0		·666

Boilers of the simple form, and without internal flues, are subjected only to one species of strain, but those constructed with internal flues are exposed to the same tensile force which pervades the simple form, and further, to the force of compression which tends to collapse, or crush the material of the internal flues. In the cylindrical boiler, with round flues, the forces are diverging from the central axis, as regards the outer shell, and converging as applied to every separate flue which the boiler contains.

These two forces in a steam boiler are in constant operation; the tendency of the one being to tear up the external plates and force out the ends, and the other to destroy the form and to force the material into the central area of the flues. These two forces operate widely different upon the resisting powers of the boiler, which taken in the direction of its exterior envelope has to resist a tensile strain operating in every direction from within, and the internal flues acting as an arch, offer a powerful resistance to compression from without. It might be instructive as well as interesting to exhibit the nature of these powers, and determine the law by which vessels of this description are retained in shape; but this can only be done by experiment, and as these experiments would have to be conducted upon a large scale, and with great accuracy, in order to arrive at satisfactory results, we must abandon the idea for the present, and content ourselves with such information as we already possess. At some future period I may possibly devote my attention to this subject; it is one of great importance, and a series of well conducted experiments would, I make no doubt, supply valuable data in the varied requirements of boiler construction, and their comparative powers of resistance to the united force of tension and compression.

From the existing state of our knowledge, we must rest satisfied with the fact, that the resisting powers of cylindrical flues to compression will be directly as their diameters, and we may therefore conclude that a circular flue, eighteen inches diameter, will resist double the pressure of one three feet diameter. Hence it follows that the resistance of wrought iron plates of the circular form is to the force of compression as their diameters—the

same, but with greatly diminished powers—as compared with the resistance of wrought iron cylindrical plates to tension.

To show the amount of strain upon a high pressure boiler 30 feet long, 6 feet diameter, having two internal flues, each 2 feet 3 inches diameter, working at a pressure of 50 lbs. on the square inch, we have only to multiply the number of square feet of surface, 1000, exposed to pressure by 3·21, and we have the force of 3319 tons, which a boiler of these dimensions has to sustain. I mention this to show that the statistics of pressure, when worked out, are not only curious in themselves, but instructive as regards a knowledge of the retaining powers of vessels so extensively used, and on which the bread of thousands depends. To pursue the subject a little further, let us suppose the pressure to be at 450 lbs. on the square inch, which a well constructed boiler of this description will bear before it bursts, and we have the enormous force of 29,871, or nearly 30,000 tons, bottled up within a cylinder of 30 feet long, and 6 feet diameter.

This is, however, inconsiderable when compared with the locomotive, and some marine boilers, which from the number of tubes, present a much larger extent of surface to pressure. Locomotive engines are usually worked at 80 to 100 lbs. on the inch, and taking one of the usual construction, we shall find at 100 lbs. on the inch that it rushes forward on the rail with a pent up force, within its interior, of nearly 60,000 tons, which is rather increased than diminished at an accelerated speed.

In a stationary boiler charged with steam at a given pressure, it is evident that the forces are in perfect equilibrium, and the strain being the same in all directions, there will be no tendency to motion. Supposing, however, this equilibrium to be destroyed by accumulative pressure till rupture ensues; it then follows that the forces in one direction having ceased, the others in an opposite direction being active, would project the boiler from its seat with a force equal to that which is discharged through the orifice of rupture. The direction of motion would depend upon the position of the ruptured part: if in the line of the centre of gravity, motion would ensue in that direction; if out of that line, an oblique or rotary motion round the centre of gravity would be the result.

The velocity or quantity of motion produced in one direction would be equal to the intensity or quantity lost; and the velocity with which the body would move would be in the ratio of the impulsive force, or the quantity lost. Therefore, the quantity of motion gained by an exploded boiler in one direction, will be as its weight and the quantity lost in that direction. These definitions are, however, more in the province of the mathematician, and may easily be computed from well known formula on the laws of motion.

We now come to the rectangular forms, or flat surfaces, which are not so well calculated to resist pressure. Of these we may instance the fire-box of the locomotive boiler, the sides and flues of marine boilers—the latter of which, by the bye, are now superseded by those of the tubular form—and the flat ends of the cylindrical boilers, and others of weaker construction.

The locomotive boiler is frequently worked up to a pressure of 120 lbs.

on the square inch, and at times when rising steep gradients, I have known the steam nearly as high as 200 lbs. on the inch. In a locomotive boiler subject to such an enormous working pressure, it requires the utmost care and attention on the part of the engineer to satisfy himself that the flat surfaces of the fire-box are capable of resisting that pressure, and that every part of the boiler is so nearly balanced in its powers of resistance as that when one part is at the point of rupture every other part is on the point of yielding to the same uniform force. This appears to be an important consideration in mechanical constructions of every kind, as any material applied for the security of one part of a vessel subject to uniform pressure, whilst another part is left weak, is so much material thrown away; and in stationary boilers, or in moving bodies, such as locomotive engines and steam vessels, they are absolutely injurious, at least so far as the parts are disproportionate to each other, and the extra weight when maintained in motion, becomes an expensive and unwieldy incumbrance. A knowledge of the strength of the materials used, judicious care, and the exercise of sound judgment in its distribution, are therefore some of the most essential qualifications of the practical engineer. Our limited knowledge, and defective principles of construction, are manifest from the numerous abortions which exist, and although I am free to communicate all that I know on this subject, I nevertheless find myself deficient in many of the requirements necessary for the attainment of sound principles of construction.

Reverting to the question more immediately under consideration, it is, however, essential to give the requisite security to those parts which, if left unsupported, would involve the public as well as ourselves in the greatest jeopardy.

The greater portion of the fire-boxes of locomotive boilers, as before noticed, have the rectangular form, and in order to economise heat and give space for the furnace, it becomes necessary to have an interior and exterior shell; that which contains the furnace is generally made of copper, firmly united by rivets, and the exterior shell, which covers the fire-box, is made of iron, and united by rivets in the same way as the copper fire-box. Now these plates would of themselves—unless supported by riveted stays—be totally inadequate to sustain the pressure. In fact, with one-tenth the strain, the copper fire-box would be forced inwards upon the furnace, and the external shell bulged outwards, and with every change of force these two flat surfaces would move backwards and forwards, like the sides of an inflated bladder, at the point of rupture. To prevent this, and give the large flat surfaces an approximate degree of strength with the other parts of the boilers, wrought iron or copper stays, one inch diameter, are introduced; they are first screwed into the iron and copper on both sides to prevent leakage, and then firmly riveted to the interior and exterior plates. These stays are about six inches asunder, forming a series of squares, and each of them will resist a strain of about fifteen tons before it breaks.

Let us now suppose the greatest pressure contained in the boiler to be 200 lbs. on the square inch, and we have $6 \times 6 \times 200 = 7200$ lbs., or $3\frac{1}{4}$ tons, the force applied to a square of 36 inches; now as these squares are supported by four stays, each capable of sustaining 15 tons, we have

$4 \times 15 = 60$ tons as the resisting powers of the stays; but the pressure is not divided amongst all the four, but each stay has to sustain that pressure, consequently the ratio of strength to the pressure will be as $4\frac{1}{2}$ to 1 nearly, which is a very fair proportion for the resisting power of that part.

We have treated of the sides, but the top of the fire-box and the ends have also to be protected, and there being no plate but the circular top of the boiler from which to attach stays, it has been found more convenient and equally advantageous to secure those parts by a series of strong wrought-iron bars, from which the roof of the fire-box is suspended, and which effectually prevents it from being forced down upon the fire. It will not be necessary to go into the calculations of those parts; they are when riveted to the dome or roof of sufficient strength to resist a pressure of 300 to 400 lbs. on the square inch. This is, however, generally speaking, the weakest part of the boiler, with the exception probably of the flat ends, above the tubes in the smoke-box, where they are not carefully stayed.

In the flat ends of cylindrical boilers, and those of the marine construction, the same rule applies as regards construction; and the due proportion of the parts, as in those of the locomotive boilers, must be closely adhered to. Every description of boiler used in manufactories, and also those on board of steamers, should in my opinion be constructed to a bursting pressure of 400 to 500 lbs. on the square inch, and locomotive engine boilers, which are subjected to a much severer duty, to a bursting pressure of 600 to 700 lbs.

It now only remains for me to state that internal flues, such as contain the furnace in the interior of the boiler, should be kept as near as possible to the cylindrical form; and as wrought iron will yield to a force tending to crush it of about one-half of what would tear it asunder, the flue should in no case exceed one:half the diameter of the boiler, and with the same thickness of plates it may be considered equally safe to the other parts. In fact, the force of compression is so different to that of tension, that I should advise the diameter of the internal flues to be in the ratio of 1 to $2\frac{1}{2}$ instead of 1 to 2 of the diameter of the boiler.

I will not trouble you with a description of the haycock, hemispherical, and wagon-shaped boilers—they are all bad as respects their powers of resistance, and ought to be entirely exploded. I shall congratulate the public when they disappear from the list of those constructions entitled to the confidence of the public, and the consideration of the man of science as well as the practical engineer.

In treating of this subject, I hope to show not only what *are* the probable causes of explosion, but what appears equally important, what *are not* the causes. So many theories (some of them exceedingly problematical) have been brought forward on the occasion of disastrous explosions, that it requires the utmost care and attention to circumstances before they are generally admitted. To acquire satisfactory evidence as to the precise condition of the boiler and furnaces before an explosion, is next to impossible, as most frequently the parties in charge, and from whose mismanagement and neglect we may in many cases date the origin of the occurrence, are the first to become the victims of their own indis-

cretion, and we can only judge from the havoc and devastation that ensues as to the immediate cause of the event.

From this it follows that, in many of the explosions on record, few if any, of the real circumstances of the case are made known, and we are left to draw conclusions from the appearance of the ruptured parts, and the terrific consequences which too frequently follow as a result. This want of evidence as to the precise condition of a boiler with all its valves and mountings, preceding an explosion, is much to be regretted, as it causes a degree of mystery to surround the whole transaction; and the vague and sometimes inaccurate testimony of witnesses, but too often baffles all attempts at research, and creates additional cause of alarm to all those exposed to the occurrence of similar dangers.

To be Continued.

For the Journal of the Franklin Institute.

Reply to the Remarks made by B. F. Isherwood, Esq., Chief Engineer, U. S. Navy, on Nystrom's Screw Propeller.

In the July number of the Journal, I find a long article, headed "Remarks on Nystrom's Screw Propeller," written by B. F. Isherwood, Esq., Chief Eng. U. S. Navy. With the permission of the Editor, I will claim the privilege of an answer—which self defence and common justice demand. J. W. Nystrom.

Mr. Isherwood asks, in his first remark, "What would be the nature of that loss of effect, if any existed? It would be shown in the *increased slip of the screw*, for the following reason: the water being thrown off radially in all directions from the axis, by the centrifugal force communicated to it by the revolving screw, there would be a vacuum about the axis, provided the centrifugal force forming the vacuum exceeded the force with which the surrounding water would flow in to fill it, and the resistance to the screw would be decreased in proportion to the extent of this vacuum; that is, the slip of the screw would be increased. *The loss of effect, therefore, due to this centrifugal force, would be furnished by the increased slip of the screw.* But if the water flowed into the vacuum as fast as it was formed, the resistance to the screw would evidently remain the same as though there were no centrifugal force in action; and this is what actually occurs in practice." This may be the fact with straight-bladed propellers, but not when the propeller is centripetal. The water flowing into the vacuum as fast as it forms, and immediately thrown out by the centrifugal force, it will act as if there were no centrifugal force. Let us look at it a little closer. Before the water comes in contact with the propeller, it has no movement; but as far as the propeller gives it movement, the effect is delivered to the water, no matter in what direction it may be.

The helicoid surface of the propeller blades acts to throw the water backwards in direction parallel to the centre line of the propeller; let its magnitude and direction be represented by the line *c b*, plate IX.; the centrifugal force of the water at the same time acts outwards in the direction of the radii; let the line *a c* represent its magnitude and direction, then the line *a b* will represent the magnitude and direction of the total

effect delivered from the propeller. The line *c b* represents the useful effect acting to propel the vessel, and the line *a c* represents the useless effect caused by the centrifugal force. If this is not clear enough, I would ask, Is it possible that the propeller can give the water a motion without expending some of its effect? And if that motion of the water is useless in propelling the vessel, the effect expended on it must be lost, it may be litttle or much; this is in regard to the straight-bladed or common propellers.

I stated, in the specification of the centripetal propeller (Vol. xxi, p. 350,) that the effect which is gained by counteracting the centrifugal force will be found by the angle the centrifugal force is acting upon. It seems Mr. Isherwood has not examined if there exists such an angle; now the question is, whether the centrifugal force acts to propel the vessel, where the propeller is centripetal.

Let a plane cut the propeller through its centre line, the section of the blades will be a curved line of the same nature as the spiral which forms the generatrix for the screw; that is, the angles *v* are proportionable at the same distance from the centre, and depends on the centrifugal force (in straight bladed propellers this section will be a straight line in the direction of the radii).

When the propeller is revolving, the water between the blades is acted by the centrifugal force upon an inclined plane, represented by the section of the blades (see plate); let the line *a c* represent the magnitude and direction of the centrifugal force in the point *a*, draw through the point *a* the tangent *t b*, draw from the point *c* a line *c d* at right angles to *t b*, then the line *c d* represents the magnitude of a force acting at right angles on the inclined plane at the point *a*; from *d* draw a line *d e* at right angles to *a c*, *then the line* d e *represents the magnitude of the force useful to propel the vessel, and caused by the centrifugal force.* Were it necessary, words could be multiplied and pages filled in the elucidation of the subject; but enough for the present. Mr. Isherwood says: "Let it then be considered the depth to which the axis of a 13-feet (mean size) is immersed, and the consequent pressure of water about it; and then the slips found in practice, ranging from 15 to 30 per cent. for maximum, and it will be seen how erroneously the effect of any centrifugal force must be exaggerated, to make it productive of a vacuum at the axis of the screw." We will look at this a moment. Suppose a propeller of 13 feet in diameter (which Mr. Isherwood calls a mean size) making 65 revolutions per minute, and a mass of water weighing 50 pounds revolve with the propeller in the periphery, the centrifugal force will be

$$C=\frac{4\times 3{\cdot}14^2\times 65^2\times 6{\cdot}5\times 50}{32{\cdot}2\times 60^2}=470 \text{ pounds;}$$

the upward pressure of that 50 lbs. of water at the depth of 13 feet will be

$$\left(\sqrt[3]{\frac{50}{0{\cdot}785\times 62{\cdot}5}}\right)^2\times 0{\cdot}785\times 62{\cdot}5\times 6{\cdot}5=322 \text{ pounds.}$$

consequently, the centrifugal force is sufficient to make a vacuum in the centre of the propeller, because the centrifugal force is 148 pounds more than the upward pressure; here the slip is not taken into consideration;

then the centrifugal force will be less. But instead of that, the centrifugal force is multiplied within the entire extremity of the periphery of the propeller; the flowing in of the water to fill up the vacuum occurs only in the centre, or around the hub, and there the stern post occupies considerable space.

But if the centrifugal force is not sufficient to cause a perfect vacuum in the hub of the propeller, it is sufficient to give the water a corresponding *irregular* and *useless motion*, which is proved to be a loss of effect.

Mr. Isherwood says: "With a straight generatrix touching the axis, the lateral component of the oblique surface of the screw is tangential to a cylinder," &c. What has this to do with the centrifugal force? But if that is the reason why the centrifugal force acts as if there was no centrifugal force, the Chief Engineer's philosophy is certainly above the comprehension of common minds.

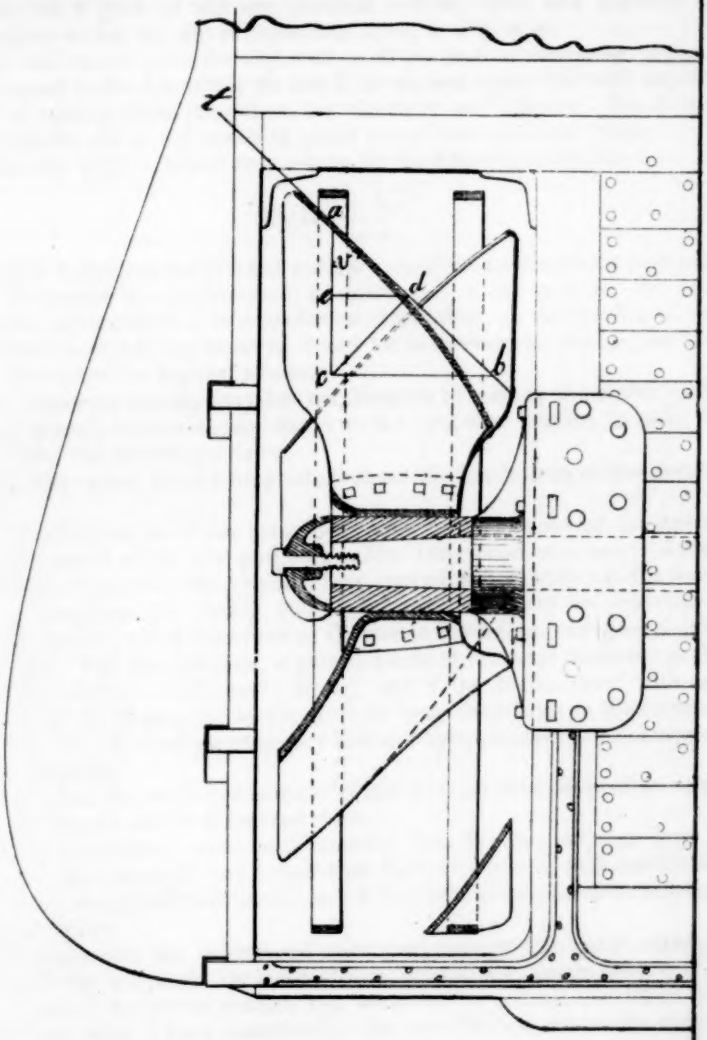
Again, Mr. Isherwood says: "The same slip, or, in other words, the same resistance is obtained from the water, with screws of equal diameter, pitch, and length, whether they have straight, inclined, or curved generatrices; for the curved generatrix is obviously but a modification of the inclined generatrix." *Only a modification of the generatrix.* That is no reason at all why the propeller should act equal in the water, if making the screw of iron and the nut also of iron, when screwed together, it will act equal with any generatrix of the screw. But the action of the propeller in the water is different; the resistance I have proved, in the foregoing, that by counteracting the centrifugal force, an additional resistance $= d\ e$ will be gained (see plate,) and acts direct in propelling the vessel.

Mr. Isherwood further states: "It is an inclined generatrix, whose inclination momentarily changes. It is therefore governed by the same principles." Of course it is; I did not say it was on any other principle. Mr. I. speaks of "the practical disadvantage and loss of labor attending the use of a curved generatrix, though none theoretically." Is it the manual labor required in making the propeller? or is it the manual labor to use the propeller when it is in the water? or is it the labor of the engine which is lost? On what principle can it be proved that the friction is greater in curved bladed propellers; and if it is so, does it not prove that the resistance is greater in propelling the vessel? Mr. Isherwood says: "Believing that sufficient has been written to put this subject in a true light," &c. We are obliged to the U. S. Chief Engineer for the *clearness* of his light, and sincerely hope its brilliancy will not serve only to make darkness visible; and as he finds it needful for the further enlightenment of the readers of the *Journal*, to notice only a few of our statements, we will listen patiently to the conclusion of the whole matter.

First, that the "water forced backwards by the blades of the screw is in directions at right angles to the surface of those blades." I did not say any such thing in my specification. I did say *in direction parallel to the axis of the propeller;* not in direction at right angles to the surface of those blades; but if I had, that does not change the shape or operation of the propeller.

Mr. Isherwood quotes my statements in regard to ocean steamers; he

NYSTROM'S CENTRIPETAL SCREW PROPELLER.



says, I give the slip of screw propellers for ocean steamers at 50 per cent.; I did not say it was a general rule; it can be more or less; but in the proportion I give of tonnage, greatest section, area, and diameter of propeller, which the slip is dependent upon, it will be so.

Mr. Isherwood gives the slip at 25 or 30 per cent. as maximum, without any regard to the quantities the slip is dependent upon; that will do very well in talking about propellers, but the facts are different. Mr. I. was very careful not to say anything about canal boats and tow boats.

The slip will be found very nearly by the following formulæ:

$$\text{Slip} = \frac{A + \sqrt[3]{D^2}}{x\,a},$$

in which A denotes the greatest section area of the displacement in square feet, D denotes the displacement in tons, and a the area for the propeller in square feet; x is a coefficient depending on the quality of the propeller, and varying between 8 and 12 or thereabout; that is, the best propeller takes the highest number.

But whatever the slip may be, the formula by which the curve is obtained, gives a corresponding shape to the propeller blades, in order to counteract the centrifugal force.

Mr. Isherwood gives a long article about the bands around the propeller:—

In practice, we need not go so deep into the philosophy of the bands; they are not at all for that purpose, as Mr. Isherwood imagines. As the blades (on the centripetal propeller) are curved, the resistance of the water acts to straighten the blades, and of course acts to give the propeller a larger diameter, which might not be allowed in the determined space for the propeller. For that purpose, a pair of bands of the same thickness as the propeller blades is sufficiently strong; and if the blades meet with any obstacle in the water, the bands serve to keep the blades in their proper position; they are really a necessary and worthy appendage to a centripetal screw propeller.

Only when the propeller is made of cast iron, or very small of wrought iron, the bands can be dispensed with.

I have a propeller, made at Gloucester Iron Works, only six feet in diameter; the wrought iron is half-inch thick at the hub, and considered sufficiently strong *without* bands; and I did not recommend them as being of great utility.

The generatrix Mr. Isherwood speaks of, must be the spiral, which is generated by warping a determined line around the circumference of a circle, called the *circles evolute*; but whatever he means, it must be different from what I have described in the specification, about the centripetal propeller, because that generatrix (spiral) has nothing to do with the tangent of an inner cylinder.

Of the experiments of which Mr. I. speaks, I would say, the generatrix to the propeller could not be calculated after the centrifugal force or velocity of the propeller. Mr. I. says: "The generatrix was tangent to an inner cylinder." Such a generatrix can not correspond with the centrifugal force, *therefore quite different from my propeller.* A fact which proves that Mr. I. has not fully examined my propeller.

I do not doubt experiments with such a generatrix would be most unsatisfactory, and it frequently happens that experiments give far different results from what was anticipated, owing to disarrangements not always fully understood.

As this is a subject of some interest, we will consider it practically. To any who feel disposed to satisfy themselves of the utility of a centripetal propeller, I will furnish one of any size, at the same rate as a common propeller; and if it does not fully answer, will refund the money.

Philadelphia, July 22d, 1851.

---

*Interesting and Unprecedented Test of Chains and Iron Rods.**

J. Foster, Esq., and the Rev. J. B. Owen, of Bilston, G. R. Hickman, Esq., of Tipton, and several other gentlemen interested in scientific experiments, attended at the cable manufactory of Mr. H. P. Parkes, Dudley, to witness some extraordinary tests of the strength and toughness of iron used in the fabrication of chains. When any one considers the frightful loss of life so frequently the result of the breaking of a single link in a chain, or the failure of a girder in an iron roof, the importance of any decided improvement in the metal and workmanship employed for such purposes cannot be too highly appreciated. Several samples of round chains, of $\frac{5}{8}$ of an inch size, were put to the hydraulic proof, and whereas the interstices between the links, previous to their tension, measured only the $\frac{1}{3}\frac{1}{2}$ of an inch, after proof it had stretched equally, even without loss of symmetry in shape, to $1\frac{5}{16}$ inch. One of these pieces of $\frac{5}{8}$ inch chain sustained without a flaw, 18·10 tons, being nearly four times the ordinary testing weight. It is due to the enterprising and intelligent experimentalist, Mr. Millington, of the firm of Messrs. W. Millington and Co., Summerhill Iron Works, Tipton, to state that of all the qualities of iron submitted to the proof, the material furnished from his works stood the severest test. Its fabric is a novelty to the trade, and will be shortly patented. Mr. Parkes has contributed a sample board of chain to the Great Exhibition, in sizes varying from $\frac{1}{4}$ to $2\frac{1}{2}$ inches, which have been tested by unprecedented proof, at his factory at Tipton. This series of experiments, probably of some importance to the Staffordshire trade, terminated, not unnaturally, with the tying-in iron of "the Staffordshire Knot." A piece of $\frac{5}{8}$ inch round of Mr. Millington's iron, formed into a nose at each end, and gracefully formed into a loose tie, was drawn in cold metal into a tight compact knot, lifting in the process the unparalleled weight of 8 tons. The chains seemed elastic as gutta percha, and stretched to nearly double their length during the proof, and like metal paralyzed, became rigid, and straight as an iron bar.

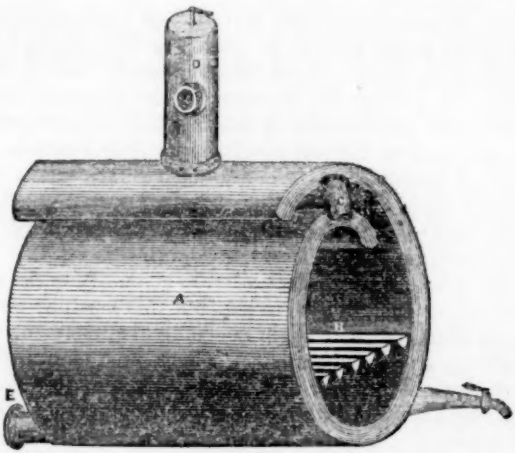
Convolute Boiler.—Registered for Messrs. Garton & Jarvis, *Exeter.*†

This boiler is intended for heated conservatories or public buildings by steam, or the circulation of hot water. Our engraving represents the boiler in perspective, with the fire-doors removed. The boiler, A, is of

*From the London Mining Journal, No. 822.

† From the Glasgow Practical Mechanic's Journal, June, 1851.

the convolute form, having the grate-bars, B, within it. It is made either of wrought or cast iron, or copper, the water space between the two parallel sheets of metal forming the volute, being three inches in breadth. The course of the draft is very obvious; it passes from the



interior of the convolute out by the open overlap, and then completely round the exterior of the boiler, which is surrounded by brick-work to form the external flue. The pipe, C, forms the water communication between the body of the boiler and the crown. The heated current of water flows off to the locality to be warmed, by the pipe, D, and the heavier cooled water returns by the bottom pipe, E. It will be seen that the peculiar feature of this arrangement, is the effective mode in which the entire internal and external surfaces are exposed to the action of the heat. Several boilers on this principle are in the exhibition.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, July 17, 1851.

S. V. Merrick, President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations were received from The Royal Astronomical Society, London; The Smithsonian Institute, and R. P. Anderson, Esq., Washington City, D. C.; Simeon Borden, Esq., Fall River, Massachussetts; Jordan L. Mott, Esq., City of New York; S. H. Palairet, Esq., George Harding, Esq., Charles E. Smith, Esq. and the Pennsylvania Railroad Company, Philadelphia.